OPERATION AND MAINTENANCE PLAN FOR AFFECTED SOURCES UNDER 40 CFR 63 SUBPART LLL

PHOENIX CEMENT COMPANY CLARKDALE, ARIZONA

Prepared for:

PHOENIX CEMENT

PHOENIX CEMENT COMPANY
P.O. Box 428
3000 West Cement Plant Road
Clarkdale, Arizona 86324

Submitted to:

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY
1110 West Washington Street
Phoenix, Arizona 85007-2935

Prepared by:

Gault Group, Inc.
2813 East Camelback Road, Suite 400
Phoenix, Arizona 85016

November 2005

TABLE OF CONTENTS

PART A

ELEMENTS OF THE OPERATING AND MAINTENANCE PLAN

1.0 INTRODUCTION

This Operations and Maintenance Plan (O&M Plan) specifies the procedures and actions that must be conducted for all affected sources under Subpart LLL of Title 40 of the Code of Federal Regulations Part 63 (40 CFR 63), and their associated air pollution control devices (APCDs), if applicable. The procedures in the O&M Plan, for proper operation and maintenance of affected sources and APCDs, are specified to ensure compliance with the applicable emission limits and operating limits of Subpart LLL.

The O&M Plan is designed to be a manual for Phoenix Cement Company (PCC) operators and technicians that are responsible for maintaining affected sources and APCDs in proper operating condition. The Plan outlines procedures for operation and maintenance to provide continuing compliance; specific actions to be taken when monitoring indicates such actions are needed; inspection procedures; opacity monitoring procedures; and required installation, calibration and quality assurance specifications for continuous opacity monitoring systems (COMS) and continuous temperature monitors.

This O&M Plan consists of two parts: Part A and Part B. Part A includes the following sections. Section 1.0 is the introduction. Section 2.0 provides a summary of all affected sources and APCDs, applicable emission limits and operating limits, and applicable monitoring requirements. Section 3.0 briefly describes general operation and maintenance for affected sources and APCDs. Section 4.0 briefly describes corrective actions to be taken when visible emissions are observed from the raw mill and finish mill APCDs. Section 5.0 provides procedures to be used during inspections of components of the combustion system of the in-line kiln/raw mill. Section 6.0 contains procedures to be used for periodic monitoring of affected sources subject to opacity standards for raw mills, finish mills, material handling and storage sources.

Part B includes specific, detailed procedures and technical documents. Section 1.0 contains specific procedures for installation, operation, calibration and maintenance of the COMS. Section 2.0 includes a detailed summary of the operation and maintenance requirements for affected-source dust collectors. Section 3.0 contains a detailed summary of the corrective actions required when visible emissions are observed during visual emissions observations. Section 4.0 includes inspection procedures for components of the combustion system of the in-line kiln/raw mill. Section 5.0 contains the specific procedures of the United States Environmental Protection Agency (EPA) Method 22 and Method 9.

2.0 Affected Sources and Applicable Requirements

Table 2-1 is a summary of affected sources, applicable emission limits, operating limits, and monitoring requirements of Subpart LLL.

TABLE 2-1: AFFECTED SOURCES AND APPLICABLE REQUIREMENTS

Process	Emission Source				Emission & Operating Limits	Monitoring Requirements
	Source No.	Dust Collector		Source Name		
Raw Grinding System No.1	AC-301	Fabric Filter NW	DC-301	Air Slide	10% opacity	Daily Method 22
	AC-302	Fabric Filter NW	DC-301	Air Slide	10% opacity	Daily Method 22
	AC-316	Fabric Filter NW	DC-301	Air Slide	10% opacity	Daily Method 22
	B-301	Norblo	DC-304	Raw Mix Bin	10% opacity	Monthly Method 22 - O&M Plan
	BC-300	Norblo	DC-304	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	BC-303	Norblo	DC-304	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	BM-301	Fabric Filter NW	DC-301	Ball Mill	10% opacity	Daily Method 22
	E-301	Fabric Filter NW	DC-301	Elevator	10% opacity	Daily Method 22
	FR-300	Fabric Filter NW	DC-301	Gas Dryer	10% opacity	Daily Method 22
	FR-301	Fabric Filter NW	DC-301	Gas Dryer	10% opacity	Daily Method 22
	SE-300	Fabric Filter NW	DC-301	Separator	10% opacity	Daily Method 22
	CY-300	Fabric Filter NW	DC-301	Cyclone	10% opacity	Daily Method 22
	CY-301	Fabric Filter NW	DC-301	Cyclone	10% opacity	Daily Method 22
	PN-301	Norblo	DC-304	FK Pump	10% opacity	Monthly Method 22 - O&M Plan
	PN-341	Norblo	DC-304	FK Pump	10% opacity	Monthly Method 22 - O&M Plan
	SC-301	Fabric Filter NW	DC-301	Screw Conveyor	10% opacity	Daily Method 22
	SC-310	Norblo	DC-304	Screw Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	W-301	Norblo	DC-304	Weigh Feeder	10% opacity	Monthly Method 22 - O&M Plan
Swing Grinding System No.2	AC-304	Norblo	DC-302	Air Slide	10% opacity	Daily Method 22
	AC-305	Norblo	DC-302	Air Slide	10% opacity	Daily Method 22
	AC-306	Norblo	DC-302	Air Slide	10% opacity	Daily Method 22
	AC-311	Norblo	DC-302	Air Slide	10% opacity	Daily Method 22

Process	Emission Source				Emission & Operating Limits	Monitoring Requirements
	Source No.	Dust Collector		Source Name		
	AC-313	Norblo	DC-302	Air Slide	10% opacity	Daily Method 22
	AC-314	Norblo	DC-302	Air Slide	10% opacity	Daily Method 22
	AC-317	Norblo	DC-302	Air Slide	10% opacity	Daily Method 22
	AC-321	Norblo	DC-302	Air Slide	10% opacity	Daily Method 22
	AC-322	Norblo	DC-302	Air Slide	10% opacity	Daily Method 22
	AC-329	Norblo	DC-302	Air Slide	10% opacity	Daily Method 22
	B-302	Norblo	DC-305	Raw Mix Clinker Bin	10% opacity	Monthly Method 22 - O&M Plan
	BC-304	Norblo	DC-305	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	BM-302	Norblo	DC-302	Ball Mill	10% opacity	Daily Method 22
	CY-302	Norblo	DC-302	Cyclone	10% opacity	Daily Method 22
	E-302	Norblo	DC-305	Bucket Elevator	10% opacity	Monthly Method 22 - O&M Plan
	FR-302	Norblo	DC-302	Gas Dryer	10% opacity	Daily Method 22
	PN-302	Norblo	DC-305	FK Pump	10% opacity	Monthly Method 22 - O&M Plan
	SC-303	Norblo	DC-302	Screw Conveyor	10% opacity	Daily Method 22
	SC-304	Norblo	DC-302	Screw Conveyor	10% opacity	Daily Method 22
	SC-308	Norblo	DC-302	Screw Conveyor	10% opacity	Daily Method 22
	SC-311	Norblo	DC-305	Screw Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	SE-303	Norblo	DC-302	Separator	10% opacity	Daily Method 22
	SE-304	Norblo	DC-302	Separator	10% opacity	Daily Method 22
	W-303	-	-	Weigh Feeder	10% opacity	Monthly Method 22 - O&M Plan
Blending and Kiln Feed	AC-607	Mikro Pul	DC-601	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-608	Mikro Pul	DC-601/602	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	S-601	Mikro Pul	DC-601	Raw Meal Silo	10% opacity	Monthly Method 22 - O&M Plan
	S-602	Mikro Pul	DC-601	Raw Meal Silo	10% opacity	Monthly Method 22 - O&M Plan
	S-605	Mikro Pul	DC-602	Homogenizing Silo	10% opacity	Monthly Method 22 - O&M Plan
	AC-609	Fuller	DC-603	Air Slide (411.AS2)	10% opacity	Monthly Method 22 - O&M Plan
	PN-601	Wheelabrator	DC-604A	FK Pump	10% opacity	Monthly Method 22 - O&M Plan
	PN-602	Fuller	DC-603	FK Pump	10% opacity	Monthly Method 22 - O&M Plan
	AC-600	Fuller/ Wheelabrator	DC-605/606	Air Slide	10% opacity	Monthly Method 22 - O&M Plan

Process	Emission Source				Emission & Operating Limits	Monitoring Requirements
	Source No.	Dust Collector		Source Name		
	AC-601	Wheelabrator	DC-606	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-601A	Mikro Pul	DC-601	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-602	Fuller	DC-605	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-602A	Mikro Pul	DC-601	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-603	Wheelabrator	DC-604A	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-604	Fuller	DC-603	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-606	Mikro Pul	DC-601	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	E-600	Mikro Pul	DC-601	Bucket Elevator	10% opacity	Monthly Method 22 - O&M Plan
Kiln Feed	AM-407	Fuller	DC-409	Alleviator	10% opacity	Monthly Method 22 - O&M Plan
	B-407	Fuller	DC-410	Bin	10% opacity	Monthly Method 22 - O&M Plan
	AC-408	Fuller	DC-410	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-409	Fuller	DC-410	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-410	Fuller	DC-410	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-413	Fuller	DC-411	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-414	Fuller	DC-410	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-415	Fuller	DC-410	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	WS-404	Fuller	DC-410	Feeder	10% opacity	Monthly Method 22 - O&M Plan
	WS-405	Fuller	DC-410	Feeder	10% opacity	Monthly Method 22 - O&M Plan
Raw Grinding System No.3	AF-360	Fuller	DC-431	Apron Feeder	10% opacity	COMS [4]
	AC-360	Fuller	DC-411	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-361	Fuller	DC-411	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-362	Fuller	DC-411	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-363	Fuller	DC-367	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-364	Fuller	DC-368	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	BC-360	Fuller	DC-366	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	BC-361	Fuller	DC-366	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	BC-363	Fuller	DC-366	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	E-360	Fuller	DC-366	Bucket Elevator	10% opacity	Monthly Method 22 - O&M Plan
	B-360	Fuller	DC-366	Raw Mill Seal Bin	10% opacity	Monthly Method 22 - O&M Plan

Process	Emission Source				Emission & Operating Limits	Monitoring Requirements
	Source No.	Dust Collector		Source Name		
	CY-360	Fuller	DC-431	Cyclone	10% opacity	COMS [4]
	CY-361	Fuller	DC-431	Cyclone	10% opacity	COMS [4]
	RM-306	Fuller	DC-431	Raw Mill	10% opacity	COMS [4]
	SE-360	Fuller	DC-431	Separator	10% opacity	COMS [4]
	BC-362	-	-	Spillage Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	PN-402	Fuller	DC-367	FK Pump	10% opacity	Monthly Method 22 - O&M Plan
	PN-403	Fuller	DC-367	FK Pump	10% opacity	Monthly Method 22 - O&M Plan
	SC-430	Fuller	DC-431	Screw Conveyor	10% opacity	COMS [4]
	SC-431	Fuller	DC-431	Screw Conveyor	10% opacity	COMS [4]
	SC-432	Fuller	DC-431	Screw Conveyor	10% opacity	COMS [4]
Pyroprocessing System	PH-404 thru 408 and K-404	Fuller	DC-431	5 Preheaters and Kiln	PM $\leq$ 0.30 lb/ton-feed 20% opacity D/F $\leq$ 0.20 ng/dscm Temperature limit [1]	COMS PM CEMS (deferred) Continuous temperature [2] Continuous pressure drop [3]
	CC-404	Fuller	DC-445	Clinker Cooler	PM $\leq$ 0.10 lb/ton-feed 10% opacity	COMS
	SC-461	Fuller	DC-445	Screw Conveyor	10% opacity	COMS [5]
	SC-462	Fuller	DC-445	Screw Conveyor	10% opacity	COMS [5]
	SC-463	Fuller	DC-445	Screw Conveyor	10% opacity	COMS [5]
	SC-465	Fuller	DC-445	Screw Conveyor	10% opacity	COMS [5]
	SC-466	Fuller	DC-445	Screw Conveyor	10% opacity	COMS [5]
	SC-467	Fuller	DC-445	Screw Conveyor	10% opacity	COMS [5]
Clinker Transport	BC-402	Fuller	DC-448	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	BC-403	Sly	DC-212	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	E-404	Fuller	DC-447	Bucket Elevator	10% opacity	Monthly Method 22 - O&M Plan
	B-404	Fuller	DC-447	Clinker Bin	10% opacity	Monthly Method 22 - O&M Plan
	DBC-404	Fuller	DC-446/447	Pan Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	VF-404	Fuller	DC-447	Vibrating Feeder	10% opacity	Monthly Method 22 - O&M Plan
Clinker Storage and Transport	BC-216	Sly	DC-213	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	BC-217	Sly	DC-214	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	BC-309	Fuller	DC-316	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan

Process	Emission Source				Emission & Operating Limits	Monitoring Requirements
	Source No.	Dust Collector		Source Name		
	HP-301	-	-	Hopper	10% opacity	Monthly Method 22 - O&M Plan
	F-301	-	-	Drag Chain Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	DO-200	Sly	DC-213	Clinker Storage Dome	10% opacity	Monthly Method 22 - O&M Plan
	DO-201	Sly	DC-214	Clinker Storage Dome	10% opacity	Monthly Method 22 - O&M Plan
	BC-310	Fuller	DC-312	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
Mill Feed / Clinker & Gypsum Handling	B-300	-	-	Gypsum Bin	10% opacity	Monthly Method 22 - O&M Plan
	B-303	Norblo	DC-306	Clinker Bin	10% opacity	Monthly Method 22 - O&M Plan
	B-340	Mikro Pul	DC-342	Clinker Bin	10% opacity	Monthly Method 22 - O&M Plan
	B-341	Mikro Pul	DC-342	Gypsum Bin	10% opacity	Monthly Method 22 - O&M Plan
	BC-303A	Norblo	DC-304	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	SC-312	Norblo	DC-306	Screw Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	W-345	-	-	Weighfeeder	10% opacity	Monthly Method 22 - O&M Plan
	BC-312	Norblo/Fuller	DC-305/312	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	BC-313	Norblo	DC-306	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	BC-350	Fuller	DC-352	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	B-350	Fuller	DC-312	Clinker Bin	10% opacity	Monthly Method 22 - O&M Plan
	B-351	Fuller	DC-312	Gypsum Bin	10% opacity	Monthly Method 22 - O&M Plan
	SC-350	Fuller	DC-352	Scavenger Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	SC-351	Fuller	DC-352	Scavenger Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	W-350	Fuller	DC-352	Weighfeeder	10% opacity	Monthly Method 22 - O&M Plan
	W-351	Fuller	DC-352	Weighfeeder	10% opacity	Monthly Method 22 - O&M Plan
Finish Mill No. BM 303	AC-307	Norblo	DC-303	Air Slide	10% opacity	Daily Method 22
	AC-308	Norblo	DC-303	Air Slide	10% opacity	Daily Method 22
	AC-309	Norblo	DC-303	Air Slide	10% opacity	Daily Method 22
	AC-312	Norblo	DC-303	Air Slide	10% opacity	Daily Method 22
	AC-315	Norblo	DC-303	Air Slide	10% opacity	Daily Method 22
	AC-318	Norblo	DC-303	Air Slide	10% opacity	Daily Method 22
	AC-323	Norblo	DC-303	Air Slide	10% opacity	Daily Method 22
	AC-324	Norblo	DC-303	Air Slide	10% opacity	Daily Method 22
	AC-330	Norblo	DC-303	Air Slide	10% opacity	Daily Method 22

Process	Emission Source				Emission & Operating Limits	Monitoring Requirements
	Source No.	Dust Collector		Source Name		
	AC-331	Norblo	DC-303	Air Slide	10% opacity	Daily Method 22
	BC-305	Norblo	DC-306	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	BM-303	Norblo	DC-303	Ball Mill	10% opacity	Daily Method 22
	CY-303	Norblo	DC-303	Cyclone	10% opacity	Daily Method 22
	E-303	Norblo	DC-306	Bucket Elevator	10% opacity	Monthly Method 22 - O&M Plan
	SC-305	Norblo	DC-303	Screw Conveyor	10% opacity	Daily Method 22
	SC-309	Norblo	DC-303	Screw Conveyor	10% opacity	Daily Method 22
	SC-306	Norblo	DC-303	Screw Conveyor	10% opacity	Daily Method 22
	SE-305	Norblo	DC-303	Separator	10% opacity	Daily Method 22
	SE-306	Norblo	DC-303	Separator	10% opacity	Daily Method 22
	PN-302	Norblo	DC-306	Pneumatic Pump	10% opacity	Monthly Method 22 - O&M Plan
	W-305	-	-	Weighfeeder	10% opacity	Monthly Method 22 - O&M Plan
Finish Mill No. BM 304	AC-340	Mikro Pul	DC-341	Air Slide	10% opacity	Daily Method 22
	AC-341	Mikro Pul	DC-340	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-342	Mikro Pul	DC-343	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-343	Mikro Pul	DC-343	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-344	Mikro Pul	DC-343	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-346	Mikro Pul	DC-343	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-347	Mikro Pul	DC-343	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	B-342	Flex-Kleen	DC-309	Fly Ash Bin	10% opacity	Monthly Method 22 - O&M Plan
	B-343	Ultra Industries	DC-308	Hydrated Lime Bin	10% opacity	Monthly Method 22 - O&M Plan
	BC-341	Wolverine	DC-344	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	BC-342	Wolverine	DC-344	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	BC-343	Mikro Pul	DC-343	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	BM-304	Mikro Pul	DC-341	Ball Mill	10% opacity	Daily Method 22
	E-340	Mikro Pul	DC-341	Bucket Elevator	10% opacity	Daily Method 22
	PN-340	Mikro Pul	DC-343	FK Pump	10% opacity	Monthly Method 22 - O&M Plan
	SC-320	Norblo	DC-306	Screw Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	SC-317	Norblo	DC-306	Screw Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	SC-316	Norblo	DC-306	Screw Conveyor	10% opacity	Monthly Method 22 - O&M Plan

Process	Emission Source				Emission & Operating Limits	Monitoring Requirements
	Source No.	Dust Collector		Source Name		
	SC-340	Mikro Pul	DC-340/341	Screw Conveyor	10% opacity	Monthly Method 22 - O&M Plan (DC340) Daily Method 22 (DC341)
	SC-341	Mikro Pul	DC-340	Screw Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	SC-342	Mikro Pul	DC-341	Screw Conveyor	10% opacity	Daily Method 22
	SE-307	Mikro Pul	DC-340	Separator	10% opacity	Monthly Method 22 - O&M Plan
	W-340	Mikro Pul	DC-341	Weigh Belt Conveyor	10% opacity	Daily Method 22
	W-341	Mikro Pul	DC-341	Weigh Belt Conveyor	10% opacity	Daily Method 22
	W-342	-	-	Weigh Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	WS-340	Mikro Pul	DC-341	Hopper w/Scale	10% opacity	Daily Method 22
	WS-341	Mikro Pul	DC-341	Hopper w/Scale	10% opacity	Daily Method 22
Clinker Grinding OK Mill	PN-350	Fuller	DC-350	FK Pump	10% opacity	Daily Method 22
	PN-351	Fuller	DC-350	FK Pump	10% opacity	Daily Method 22
	AC-350	Fuller	DC-350	Air Slide	10% opacity	Daily Method 22
	AC-351	Fuller	DC-350	Air Slide	10% opacity	Daily Method 22
	AC-352	Fuller	DC-350	Air Slide	10% opacity	Daily Method 22
	AC-353	Fuller	DC-350	Air Slide	10% opacity	Daily Method 22
	AC-354	Fuller	DC-350	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	B-352	Fuller	DC-352	Surge Bin	10% opacity	Monthly Method 22 - O&M Plan
	BC-351	Fuller	DC-352	Belt Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	AF-351	Fuller	DC-352	Apron Feeder	10% opacity	Monthly Method 22 - O&M Plan
	E-350	Fuller	DC-352	Bucket Elevator	10% opacity	Monthly Method 22 - O&M Plan
	DCH-350	Fuller	DC-352	Chain Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	DCH-351	Fuller	DC-352	Chain Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	RM-305	Fuller	DC-350	OK Mill	10% opacity	Daily Method 22
	SC-510	Fuller	DC-510	Screw Conveyor	10% opacity	Monthly Method 22 - O&M Plan
	SE-308	Fuller	DC-350	Separator	10% opacity	Daily Method 22
Sacking	BP-501	BHA	DC-501	Bag Packer	10% opacity	Monthly Method 22 - O&M Plan
	BE-501	BHA	DC-501	Bucket Elevator	10% opacity	Monthly Method 22 - O&M Plan
	BP-502	BHA	DC-505	Bag Packer	10% opacity	Monthly Method 22 - O&M Plan
	BE-502	BHA	DC-505	Bucket Elevator	10% opacity	Monthly Method 22 - O&M Plan

Process	Emission Source				Emission & Operating Limits	Monitoring Requirements
	Source No.	Dust Collector		Source Name		
Bulk Loading	AC-507	Mikro Pul	DC503	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-509	Pangborn	DC-504	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-513	Pangborn	DC-505	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-506	Mikro Pul	DC-503	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-514	Pangborn	DC-505	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-501	Pangborn	DC-501	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-511	Pangborn	DC-501	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-516	Pangborn	DC-505	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-519	Mikropul	DC-507	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-518	Mikropul	DC-507	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-502	BHA	DC-501	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-503	BHA	DC-501	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-504	BHA	DC-501	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-505	Fuller	DC-510	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-508	Pangborn	DC-504	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-510	BHA	DC-501	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-511	BHA	DC-501	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	AC-512	BHA	DC-501	Air Slide	10% opacity	Monthly Method 22 - O&M Plan
	PN-501	BHA	DC-501	Pneumatic Pump	10% opacity	Monthly Method 22 - O&M Plan
Cement Storage	S-15	Fuller	DC-512	Silo 15	10% opacity	Monthly Method 22 - O&M Plan
	S-16	Fuller	DC-512	Silo 16	10% opacity	Monthly Method 22 - O&M Plan
	S-1	Ecolaire	DC-508	South Finish Silo 1	10% opacity	Monthly Method 22 - O&M Plan
	S-2	Ecolaire	DC-508	South Finish Silo 2	10% opacity	Monthly Method 22 - O&M Plan
	S-6	Ecolaire	DC-508	South Finish Silo 6	10% opacity	Monthly Method 22 - O&M Plan
	S-7	Ecolaire	DC-508	South Finish Silo 7	10% opacity	Monthly Method 22 - O&M Plan
	S-11	Ecolaire	DC-508	South Finish Silo 11	10% opacity	Monthly Method 22 - O&M Plan
	S-12	Ecolaire	DC-510	South Finish Silo 12	10% opacity	Monthly Method 22 - O&M Plan
	S-3	Fuller	DC-510	Cement Silo 3	10% opacity	Monthly Method 22 - O&M Plan
	S-4	Fuller	DC-510	Cement Silo 4	10% opacity	Monthly Method 22 - O&M Plan
	S-5	Fuller	DC-510	Cement Silo 5	10% opacity	Monthly Method 22 - O&M Plan

Process	Emission Source				Emission & Operating Limits	Monitoring Requirements
	Source No.	Dust Collector		Source Name		
	S-8	Fuller	DC-510	Cement Silo 8	10% opacity	Monthly Method 22 - O&M Plan
	S-9	Fuller	DC-510	Cement Silo 9	10% opacity	Monthly Method 22 - O&M Plan
	S-10	Fuller	DC-510	Cement Silo 10	10% opacity	Monthly Method 22 - O&M Plan
	S-13	Fuller	DC-510	Cement Silo 13	10% opacity	Monthly Method 22 - O&M Plan
	S-14	Fuller	DC-510	Cement Silo 14	10% opacity	Monthly Method 22 - O&M Plan

[1] When the raw mill is operating, temperature of the main in-line kiln/raw mill exhaust gases must not exceed the applicable temperature limit established in the most recent performance test when the raw mill was operating. When the raw mill is not operating, temperature of the main in-line kiln/raw mill exhaust gases must not exceed the applicable temperature limit established in the most recent performance test when the raw mill was not operating.

[2] A continuous monitor is required to record the temperature of the exhaust gases from the main in-line kiln/raw mill at the inlet of the PM control device.

[3] Until a PM CEMS is installed and operated, pressure drop across the PM control device will be continuously monitored to demonstrate operation within the designated indicator range. After the PM CEMS is installed, the pressure drop monitor will no longer be required.

[4] COMS is required for Kiln (K-404) / dust collector (DC-431). DC-431 also controls this equipment/process.

[5] COMS is required for Clinker Cooler (CC-404) / dust collector (DC-445). DC-445 also controls this equipment/process.

3.0 OPERATION AND MAINTENANCE PROCEDURES

3.1 KILN AND CLINKER COOLER

Operators of the in-line kiln and raw mill, and the clinker cooler shall operate these affected sources according to the Installation, Operation and Maintenance Procedures specified by F.L. Smidth Inc (FLS) to optimize combustion conditions. Particulate (PM) and visible emissions from the kiln/raw mill are controlled by a Fuller 259,200 acfm fabric filter baghouse (DC-431); and clinker cooler emissions are controlled by a Fuller, 138,000 acfm fabric filter baghouse (DC-445). Both baghouse exhaust streams are monitored by Rosemount Analytical transmissometers. In addition, both baghouses are continuously monitored to demonstrate pressure drop indicator ranges are not exceeded.

3.2 COMS

"COMS Procedures" are provided in Part B, Section 1.0 of this O&M Plan, for operation and maintenance procedures, and specifications for the COMS that monitor opacity from DC-431 and DC-445. The Rosemount Analytical manual specifies complete installation, alignment, operation, troubleshooting, and preventative maintenance procedures to be followed by PCC operators and technicians.

3.3 DUST COLLECTORS

Part B, Section 2.0, of this O&M Plan provides a detailed summary of the operation and maintenance requirements for all dust collectors controlling PM emissions from affected sources (identified in Table 2-1) under 40 CFR 63, Subpart LLL.

4.0 CORRECTIVE ACTIONS

Part B, Section 3.0 of this O&M Plan provides a detailed summary of the corrective actions required (when visible emissions are observed) for dust collectors controlling PM emissions from affected sources (identified in Table 2-1) under 40 CFR 63, Subpart LLL.

This O&M Plan is required to include corrective actions to be taken when required by paragraph (e) of Section 63.1350 of Subpart LLL. Paragraph (e) of that section requires daily, six-minute visual emissions observations of mill sweep and air separator PM control devices for affected raw mills and finish mills. The visual emissions observations must be conducted in accordance with the procedures of EPA Method 22 and conducted while the affected raw mill or finish mill is operating at the highest load or capacity level reasonably expected to occur within the day. If visible emissions are observed, specific actions must be taken, as summarized below:

- Initiate, within one hour, the corrective actions specified in the O&M Plan (Part B, Section 3.0); and

- Within 24 hours of the end of the Method 22 test in which visible emissions were observed, conduct a visual opacity test of each stack from which visible emissions were observed in accordance with EPA Method 9. The duration of the Method 9 test shall be 30 minutes.

5.0 PROCEDURES FOR COMBUSTION SYSTEM INSPECTIONS

The components of the combustion system of the in-line kiln/raw mill shall be inspected at least once per year. Part B, Section 4.0 of this O&M Plan provides comprehensive inspection procedures.

6.0 OPACITY MONITORING PROCEDURES

As shown in Table 2-1, opacity standards apply to all Subpart LLL affected sources and periodic monitoring requirements are listed for each source. The following paragraphs specify monitoring procedures to be followed for each type of monitoring listed in Table 2-1.

1. <u>Monthly Method 22 (O&M Plan)</u> – At each affected source for which Table 2-1 specifies "Monthly Method 22 (O&M Plan)", conduct a one-minute visible emissions test in accordance with the EPA Method 22 procedures provided in Part B, Section 5.0. *Initially*, the one-minute Method 22 test must be conducted on a monthly basis.

If no visible emissions are observed in six consecutive monthly tests of any affected source, the frequency of testing may be decreased from monthly to semi-annually for that affected source. If visible emissions are observed during any semi-annual test, a monthly testing frequency must be resumed for that source, and the monthly schedule must be maintained until no visible emissions are observed in six consecutive monthly tests.

If no visible emissions are observed during the semi-annual test of any affected source, the frequency of testing may be decreased from semi-annually to annually for that affected source. If visible emissions are observed during any annual test, a monthly testing frequency must be resumed for that source and the monthly schedule must be maintained until no visible emissions are observed in six consecutive monthly tests.

If visible emissions are observed during any Method 22 test, a six-minute test of opacity must be conducted in accordance with EPA Method 9 (Part B, Section 5.0). The Method 9 test must begin within one hour of any observation of visible emissions.

2. <u>Daily Method 22</u> – At each affected source for which Table 2-1 specifies "Daily Method 22", conduct a six-minute Method 22 visible emissions test while the mill is operating at the highest expected capacity. Conduct each test on a daily basis. If visible emissions are observed, corrective action must be initiated within one hour (Part B, Section 3.0). Conduct a 30-minute Method 9 test within 24 hours of the observation of visible emissions.

3. COMS shall be operated, calibrated and maintained according to the recommendations of the manufacturer (Part B, Section 1.0).

PART B

SPECIFIC PROCEDURES AND TECHNICAL DOCUMENTS

SECTION 1.0

CONTINUOUS OPACITY MONITORING SYSTEMS INSTALLATION, OPERATION AND MAINTENANCE PROCEDURES

11/2002 Rev.2

DURAG

D-R 290
Dust and Opacity Monitor
Installation and Operation

DURAG Durag, Inc
1355 Mendota Heights Road Ste. 200 · Mendota Heights, MN 55120
Tel. 651-451-1710 · Fax 651-457-7684

Contents

Figures

Valid for PROM version 2.00 and higher

Document : man_dr290_R1

Date : ***September 2001***

1. Applications

The Durag D-R 290 opacity monitor can be used for continuous emissions monitoring in smokestacks, exhaust ducts, and other similar applications. This monitor has been designed to comply with the new Performance Specification 1 found in 40 CFR part 60, Appendix B and the ASTM D6216-98 standard.

This type of opacity monitor is necessary for the legal and economically sound operation of power plants, heating plants and other industrial large boiler facilities. These systems are also critical for use in the chemical and cement industries where careful monitoring of the industrial processes is a criterion for problem-free operation.

Durag opacity monitors have functioned successfully for years in applications where dust emissions could have potentially damaging environmental pollution effects. The data they collect is incorruptible, precisely reproducible, unaffected by seasonal changes or weather conditions, and functions easily in either automatic or manual operation. These systems have been used for applications in refineries and other facilities of the petrochemical industry, in waste-burning facilities and many others.

2. Basic Features

- Continuous, *in situ* measurement directly in the exhaust stream without disruption or dust sampling.
- The white light semi-conductor light source has a long life.
- The wide spectrum of the Super-Wide Band Diode (SWBD) optimizes system accuracy because the measurements are more stable than those made with conventional LEDs.
- Modern microprocessor technology and software allow digital information processing.
- LCD shows measurements as opacity or extinction.
- Automatic calibration cycle corrects values for window contamination.
- Purge air system protects the reflector and heated exit window reduce maintenance.
- Control panel with digital display makes installation and operation simple.
- Hermetically sealed optics and electronics prevent dust or smoke from damaging internal system components. Two analog outputs with selectable measuring ranges on each system.

Optional

- Fail-safe shutter system protects the transceiver and reflector.
- Protective weather hoods for transceivers, reflectors, and purge air systems.
- Stack mounted display for single person filter audits.

3. Operating Overview

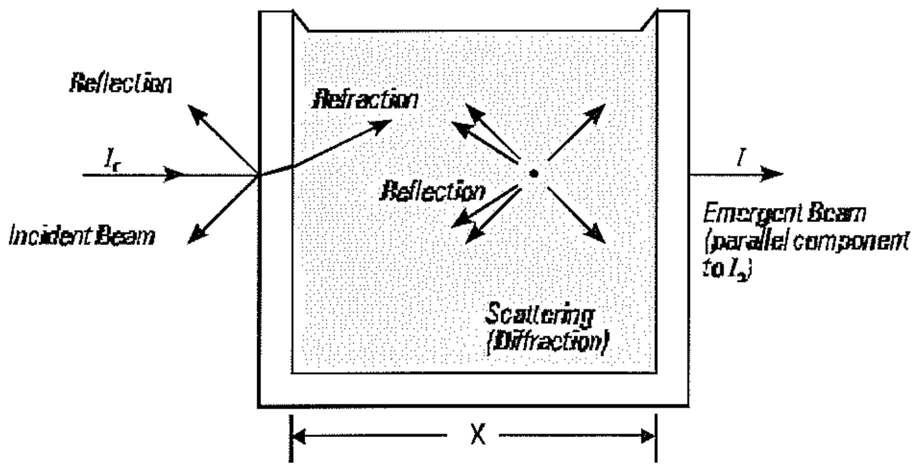
The transceiver emits a beam of light which passes through the stack or duct and strikes a reflector. The light beam is reflected back and the amount of light returned is measured by the transceiver. Dust particles in the stack will absorb and scatter the transmitted beam of light so the returned light will be less than the transmitted light. The ratio of the returned light to the transmitted light is call the transmission. One minus the transmission is referred to as opacity. For dust concentration measurements optical density (also called extinction) is historically used because the dust concentration is linear to the optical density value. The log of 1 divided by the transmission give the optical density.

The measured transmission value is sent via RS 422 to the stack display (D-R 290 AZ). From this local display the measured value can be read and maintenance actions can be initiated. Also purge air alarms are wired into this stack display. From here the measured value and any purge air failure is sent via RS422 to the evaluation unit (D-R 290 AW).

At the evaluation unit the measured value is displayed and system parameters can be viewed or changed. This remote display also contains the status inputs, relay outputs and the 2 independent current outputs. One current output could be set to read opacity and the other to read the dust concentration. If dust concentration is required, normally a stack test is need to calibrate the extinction reading to a concentration (determine the extinction coefficient).

Purge air blowers are used to keep the optics clean. Weather hoods are used to protect the blowers and the opacity system. Fail safe shutters can be installed to protect the optics if a purge air blower should fail or loose power and may also protect service personnel on over pressure stacks. These shutters are exercised during the daily calibration to insure they are in working order when needed and to prevent them from sticking in the open position.

The Durag D-R 290 opacity monitor is designed to utilize the principles of light transmission. The transceiver and reflector are mounted opposite one another. Using the auto collimation principle, the light beam traverses the distance to be measured twice. This significantly increases the sensitivity of the measurements made by the system.



The light beam loses intensity proportionally to the particle concentration of the air. The light beam has a significantly larger diameter than the reflector surface. This makes alignment easier and reduces measurement errors caused by possible heat-induced shifts in the transceiver or reflector mounting flanges.

3.1. Transmission Measuring Principle

If a light shines through a smoke stack or dust exhaust duct, this light beam will become weaker as the dust density increases.

Transmission is the ratio of the intensity of the light received *(I)* compared to the intensity of the light transmitted (I_0).

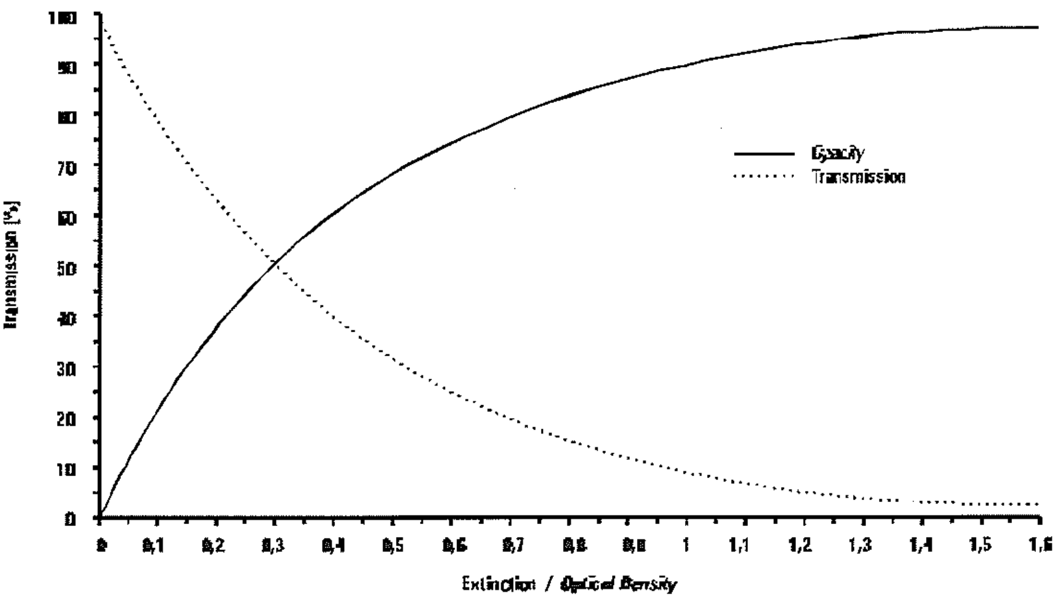
$$\frac{I}{I_0} \qquad \text{Eq.1}$$

The relationship between the irradiated light and the received light is given as a percent value, as shown in equation 2.

$$\frac{I}{I_0} \times 100\% = T \qquad \text{Eq.2}$$

Subtracting the transmission measurement from one gives the opacity value. Opacity is the default measurement mode of the D-R 290, since this results in an increasingly strong signal at the detector as the dust density diminishes.

$$100\% - \frac{I}{I_0} \times 100\% = OP \qquad \text{Eq.3}$$



(Fig. 3.1) Relationship between Extinction, Transmission and Opacity

Because the D-R 290 operates on the auto collimation principle, the light beam being measured crosses the measurement region twice. This means that the measurement light beam will lose the same percentage of intensity on each pass through the dust particles in the exhaust air.

Since an observer looking at the stack exit is only looking through the plume once, the D-R 290 will correct the double pass measurement and the opacity reading as a single pass measurement at the stack outlet.

3.1. Opacity Calculation at the Stack exit

Op = Single pass opacity at the measurement point.

Op1 = Double pass opacity at the measurement point measured using the auto collimation principle.

Op2 = Single pass opacity at the stack exit.

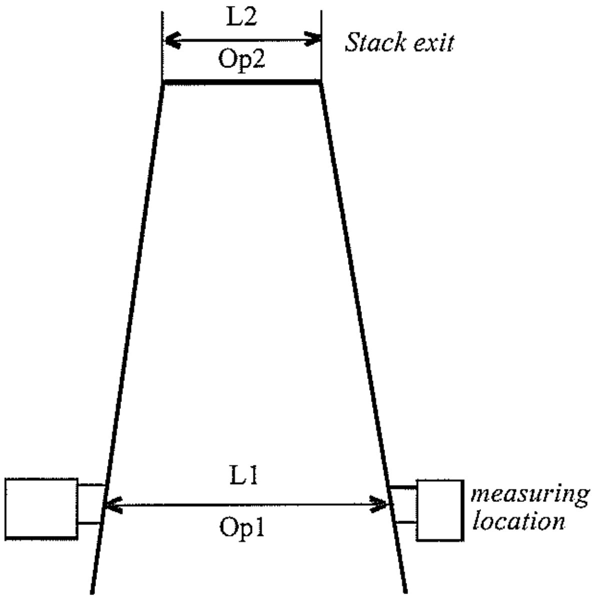
L1 = Diameter of the stack at the measurement point.

L2 = Diameter of the stack at the stack exit.

Eq.4

If both losses of light intensity from the measurement beam passes are taken into account, the following equation (Eq. 5) can be used to calculate the opacity at the stack exit:

$$Op2 = 1 - (1 - Op1)^{\frac{L2}{2\,L1}} \qquad \text{Eq.5}$$



(Fig. 3.2) Reference locations for determining opacity

Since the data must be evaluated as if the measured light beam has crossed the stack opening a single time, the D-R 290 system can make these corrections. This means that the stack correction factor L2/L1 must be entered into the control unit. This value can be set as shown in section 6.5. Once set, the stack correction factor is used in all opacity measurement ranges on both measurement channels.

For example:

Measurement location	= 6.00 ft	= L 1	
Stack exit	= 5.10 ft	= L 2	
Stack correction factor	$\square$	$= \frac{5.10 ft}{6.00 ft}$	= 0.850

The stack correction factor is set by DURAG using information supplied by the customer based upon the specific stack dimensions. If this needs to be changed, please contact DURAG for assistance.

3.2. Extinction Measurement Principle

If a beam of light shines through a flue gas channel or dust extraction line, the light intensity will attenuate as the dust concentration ***C*** increases. This loss of light intensity is caused by absorption and diffraction, collectively referred to as extinction. Generally, the light intensity ***I*** decreases exponentially as the path length ***L*** increases.

$$I = I_o \cdot e^{-KLC}$$

Eq.6

In calculating the measured dust intensity, I_o is the constant for the emitted light intensity and ***L*** is the constant value of the measured path length. The value of the extinction constant ***K*** can then be determined. In general, the dust concentration (in grain/ft^3 or mg/m^3) has a linear relationship to extinction. Many parameters, however, will vary at different installations including particulate size, composition of the particles, specific weight, index values, and the absorption constant for the light being used. In many installations, the load of the facility will affect the size of the dust particles. Wet (whether steam of condensation-based) and dry filtering systems will also influence the particulate exhaust. Thus, the exact relationship between the extinction value the monitor displays and the actual dust emissions should be determined through gravimetric measurement.

$$E = lg\left(\frac{1}{T}\right) = lg\left(\frac{Io}{I}\right)$$

Eq.7

Solving equation 6 allows the derivation of the extinction constant ***K*** as shown below:

$$K = \frac{\ln\left({}^{I_o}\!/_{I} \right)}{C \cdot L}$$

Eq.8

To express the extinction constant ***K*** in a linear relationship to the dust concentration ***C***, the values of the measurement and comparison light beams are written as a part of log functions.

The dust concentration *C* is:

$$C = \frac{\ln\left(I_o / I \right)}{K \cdot L} \qquad \text{Eq.9}$$

Io = Emitted light

I = Received light

L = Measuring path length (for Auto collimation ∗ 2)

K = Extinction coefficient

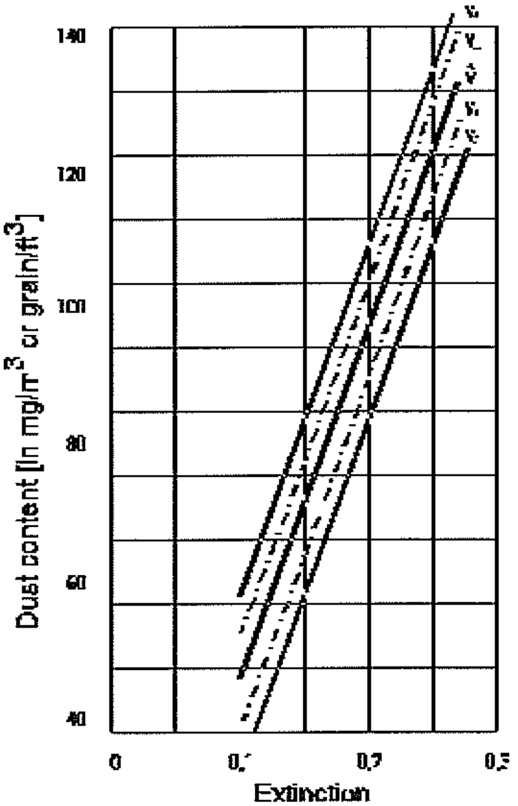
E = Extinction

c = Dust concentration

For the reasons above, dust concentration **c** must be determined by gravimetric measurement. The necessary measurement must be carried out at the expected plant loads and the expected filter settings of the respective plant. When changing fuel types, checking the measurements is necessary. Only when these comparison values are available can the extinction values in respect to the particulate emissions be correctly evaluated. As dust concentration readings are subject to fluctuations, most favorable are statistical methods for determining the calibration curve for the relationship between extinction and dust concentration.

See DIN 1319 p. 3 ‘Fundamentals of Measuring Techniques’ and DIN 55302 p.1 and 2 ‘Statistic evaluation procedures, frequency distribution, mean value and scattering’, as well as VDI 2066 ‘Dust measuring in streaming gases’.

The compensating straight-line, which is drawn through the measuring points, is established to the ‘smallest quadratic error’ method. It is also designated as regression straight-line (Ý). The (*Y1*, *Y2*) lines represent the reliability range, i.e., the mean value of extinction *x* obtained over a long period lies with a probability of 95% between *Y1* and *Y2*. Two further lines (*Y3*, *Y4*) define the tolerance range. This means that as a result of many gravimetric dust measurements at the indicated extinction value *x*, at least 75% of the spot-checked dust contents will lie with 95% probability in the tolerance range between *Y3* and *Y4*.



3.4 Principle of Operation

The D-R 290 operates according to the principle of autocollimation (double-pass). The lightbeam crosses the measuring path twice. The system measures and evaluates the attenuation of the light beam caused by the dust in the measuring path.

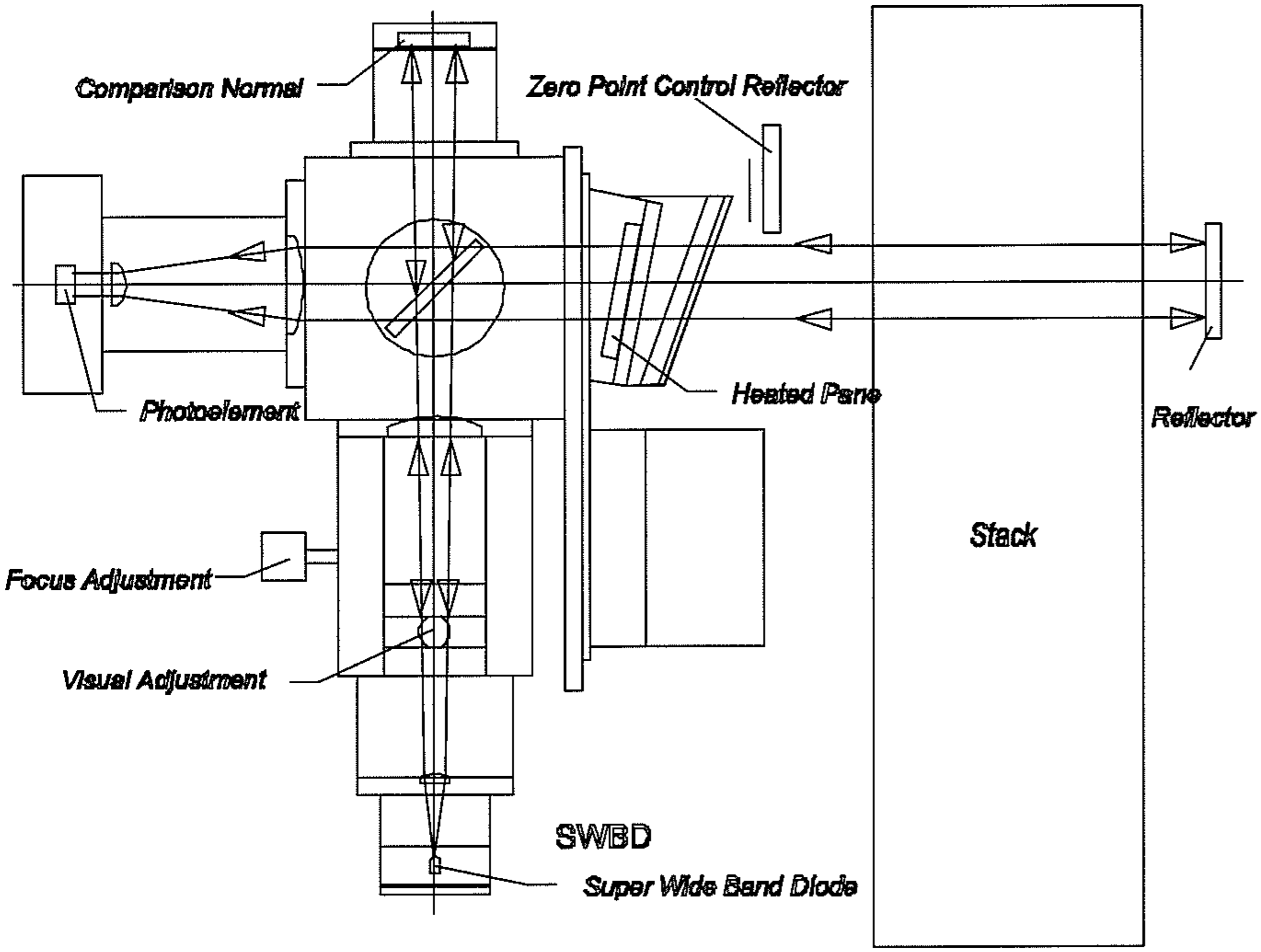
The two main features that separate the D-R 290 from the older designs of the competition are the Super Wide Band Diode and the single detector optical design.

The Super Wide Band Diode with a spectral response of 400 to 700 nm is modulated with no moving parts. This modulation prevents influences from other light sources such as sunlight. The broad band light source minimizes the effects of changing particle sizes when measuring dust concentration. The calibration audit filters typically used are measured over the 400 to 700nm range. The broad spectrum light source will give a more accurate measurement of these filters when compared to a narrow band LED system. Optical techniques are employed to ensure a homogeneous light beam without "hotspots". This light is then split by a beam splitter to form a measurement light beam and a comparison light beam. The measurement light beam passes through the dust in the stack, enters the optic head, passes through the beam splitter and is measured by the detector.

Since the basis for all opacity monitors is the measurement of transmission (the amount of light received divided by the amount of the light transmitted), it is very important that not only the received light be measured accurately, but the transmitted light as well. Every 2 minutes the measurement light path is briefly blocked and only the comparison light path is evaluated. The comparison light beam is measured to determine the amount of the transmitted light. This comparison light path uses the same light source as the measured light path, passes through the beam splitter once, and is reflected once – just like the measured signal – and is measured by the same detector used to measure the light beam from the measuring reflector. Using this optical design, any change in the amount of light from the source, contamination of the beam splitter, or drift in the detector will effect both light paths (comparison and measurement) by the same amount and no error will be introduced to the opacity measurement.

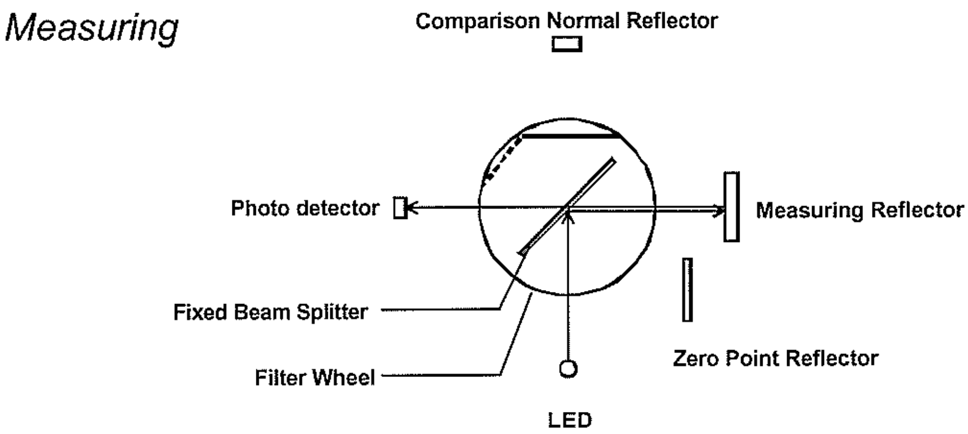
A control cycle is initiated periodically to ensure proper operation of the system. During this cycle, the D-R 290 automatically measures and displays the zero point, window contamination, upscale calibration value, and stack taper ratio. If necessary, the subsequent measured values will be corrected for window contamination. If the correction exceeds a predetermined value, a warning signal will be generated.

An integrated filter holder in the transceiver and a local display allow for quick and easy quarterly audits. The local display also allows service or maintenance by a single technician. Diagrams of the optics are given on the following pages.



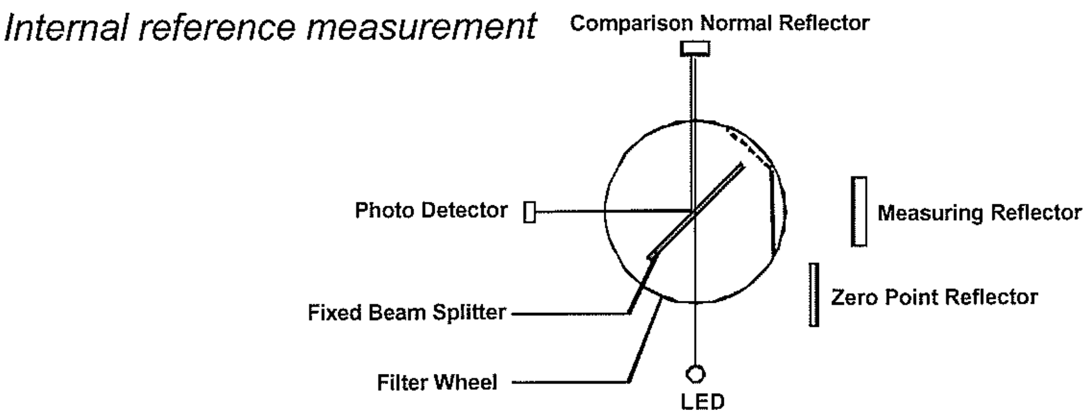
(Fig. 3.3) Optics diagram D-R 290

3.4.1 Measurement



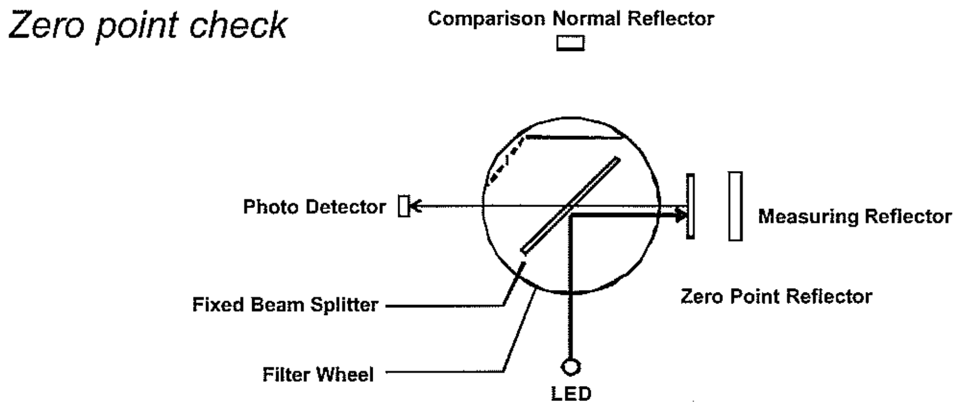
The unavoidable drifts in light intensity that result from aging of the light source or temperature changes are automatically compensated by the monitor. The 2 kHz modulated light is split into both a measurement light beam and a comparison normal. An optical receiver (photoelement) alternately reads these light beams. The selection of the light paths is driven by a stepper motor.

3.4.2 Internal Reference



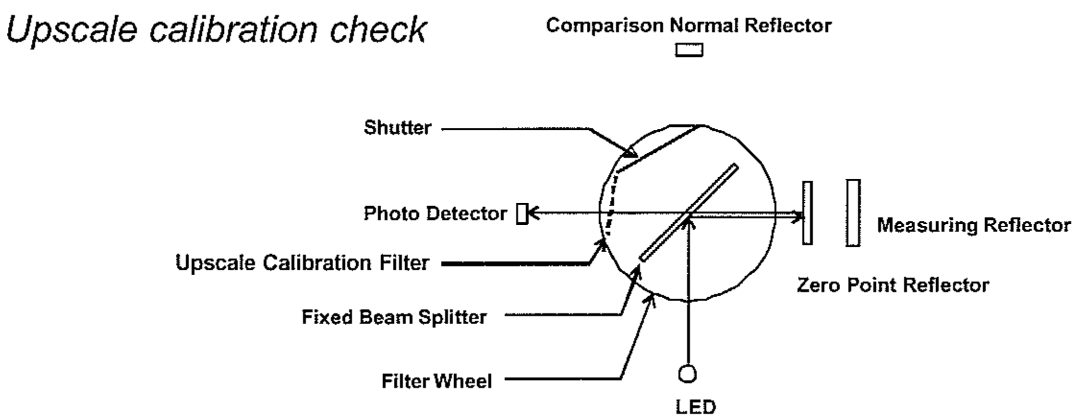
Every 2 minutes, for a period of 2 seconds, the opacity measurement is interrupted and an internal reference measurement (also called comparison normal) is performed. The filter wheel driven by a stepper motor moves the opaque filter from in front of the comparison normal reflector to a position in front of the measuring reflector. The light beam of interest leaves the LED and passes through the beam splitter. The light that was reflected from the beam splitter hits the opaque filter and is wasted. The light beam that passed through the beam splitter travels to the comparison normal reflector and is reflected. It travels to the beam splitter where the beam is reflected to the photo-detector. This value is digitized and stored in memory. This is how the system monitors the intensity of the LED. If the LED intensity is higher or lower than expected, the system can lower or raise the LED current by one step each 2 minute reference measurement cycle. In this way the light intensity of the system is held constant.

3.4.3 Internal Zero Check

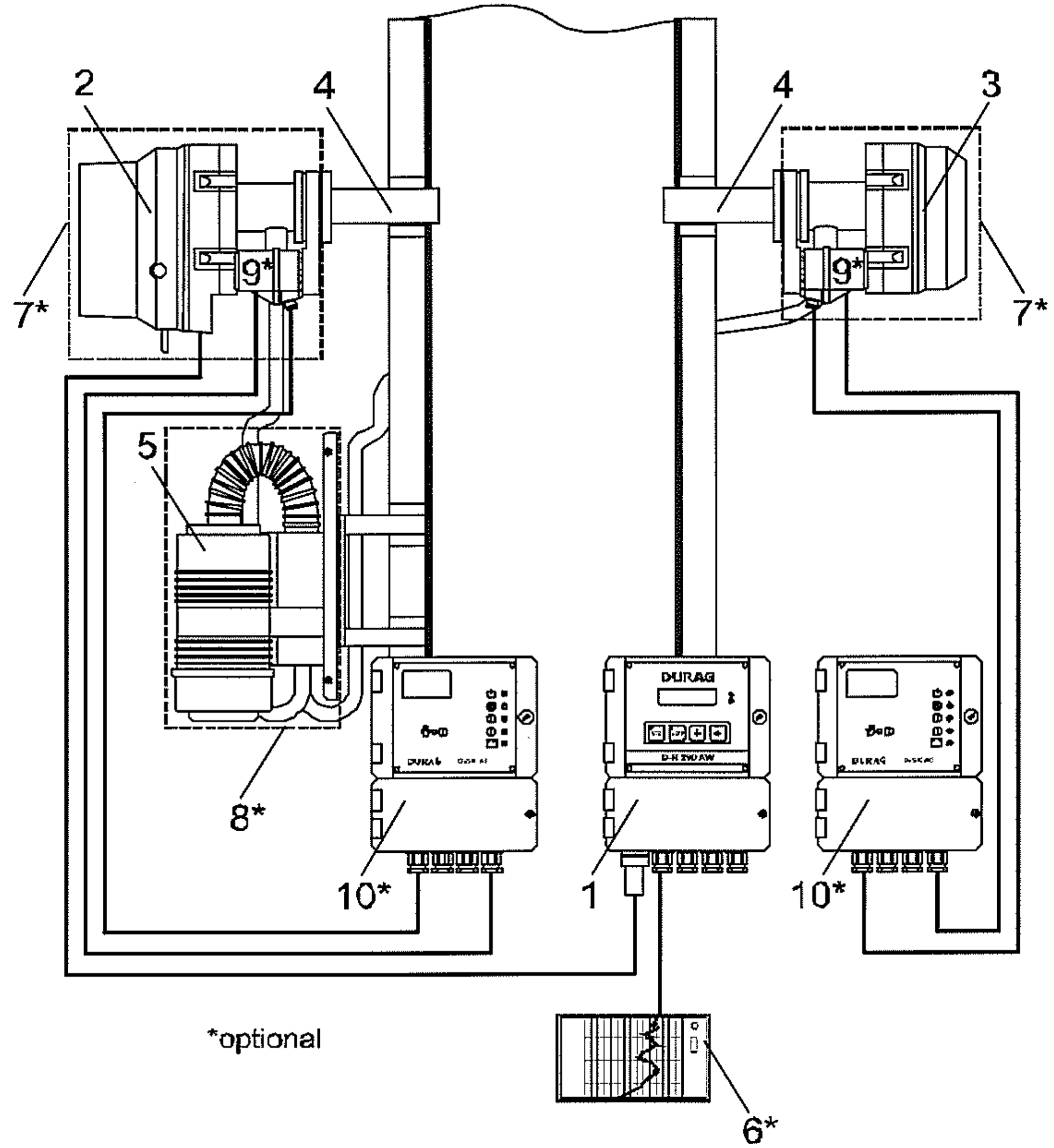


To make sure the D-R 290 system is operating properly, a control cycle runs at regular intervals, which can be set to occur every 1-99 hours or can be initiated by the data logger. This cycle automatically measures and displays the zero point value, the level of window contamination on the optical surfaces, and a control value. All subsequent measurements are then adjusted to correct for the window contamination values. The acceptable value for this window contamination can be selected in %; if the value becomes higher, a warning message will be displayed (relay output). The control panel electronics then calculate the transmission intensity based on the light it receives and the intensity of the comparison normal beam. This data is then used in the calculation of the opacity or the extinction value. The extinction can be calibrated and is displayed in mg/m^3 ($grain/ft^3$). The result is then both displayed and given as an analog current output signal.

3.4.4 Upscale Calibration Check



3.5 System Components



(Fig.3. 4) System components

	Standard		*** Optional**
1	Control unit, D-R 290 AZ (stack display) Or D-R 290 AW (evaluation unit)	6	Customer supplied recorder or data logging system
2	Transceiver, D-R 290 MK	7 & 8	Weather Hood, US built systems use one
3	Reflector, D-R 290 R1 or R2		Large weather hood for blower and optics
4	Mounting flange, D-R 280 E	9	Fail-safe shutters
5	Purge air unit	10	Fail-safe shutter control electronics

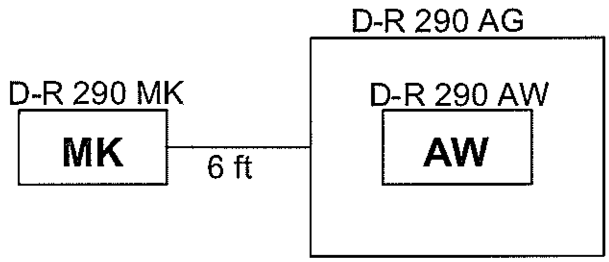
Figure 4 shows standard and optional system components. Due to the many types of different applications, it is difficult to show all the different configurations of various components. DURAG, Inc. is committed to supplying the right system for the customer's particular application. There have been applications where weather hoods are not required, where only one shutter is used on the transceiver, or where one larger blower is used due to space constraints, 2 larger blowers have been used to overcome stack pressure, various adapter flanges have been used to mate with existing stack flanges, etc. Please consult with DURAG, Inc. for specific application recommendations.

The system components are briefly described below. A more detailed description is given in the installation section of this manual.

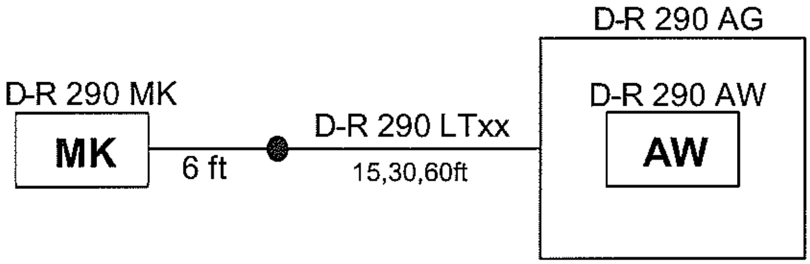
1. **Stack Display Unit D-R 290 AZ**: This consists of an electronic insert (D-R 290 AZ) that is mounted in a housing with a terminal strip (D-R 290 AG). The insert in the housing will be called the D-R 290 AZG. This serves as the power supply for the transceiver, display unit of the measured values and system parameters, I/O termination point for shutters and pressure cells for blower alarms. This unit also relays the RS 422 information between the transceiver and the control room display unit. Calibration functions and the quarterly audit filters tests can be initiated from the D-R 290 AZG. This is part of the standard system although not required. It is possible to operate the system without the D-R 290 AZG and only with the Control Room Display Unit D-R 290AW.
   Evaluation Unit D-R 290 AW: This serves as the "brains" for the opacity system. This uses the same electrical hardware as the D-R 290 AZ but different software. This is typically mounted in a 19" rack using a D-R 290 BT rack mount housing. It can also be wall mounted in a D-R 290 AG housing. The D-R 290 AW serves a display unit, all the system parameters are entered with the key pad, and all the I/O for the data logging system is terminated here.
2. **Transceiver D-R 290 MK**: This transmits light to the reflector and receives the light from the reflector. The D-R 290 MK contains the modulated white LED light source, the detector, and the hardware for performing the daily calibration checks.
3. **Reflector D-R 290 R1** or **D-R 290 R2**: Both these types of reflectors auto-collimate the light. This means the light that hits the reflector is returned parallel to the incoming light (back to the transceiver). The R1 reflector is a "scotchlite" material and is for use with flange to flange distances up to 7.4 ft. (2.25m). The R2 reflector is a glass corner cube and can be used from distances of 5.7 ft. (1.75m) to 46 ft. (14m).
4. **Stack Flange D-R 280 E**: This is used to support the monitor on the stack. Different versions are available for brick stacks as well as to adapt to existing flanges.
5. **Purge Air Unit**: This is a centrifugal blower, typically ½HP, with one used on the transceiver side of the stack and one on the reflector side. When larger than standard stack flanges are used (existing) or when the stack is positive pressure a larger blower may be used. Normally these blowers are mounted below the transceiver or the reflector inside the weather hood.
6. **Recording device**: Durag can supply a chart recorder but normally the customer has a recorder or data logging system to use to record the data.
7. **Weather Hoods for transceiver and reflector**: This is a large fiberglass box with a hinged cover to protect stack opacity components from the weather and birds. Normally the purge air system is mounted inside this box below the transceiver or reflector for US built systems. Typically there is one weather hood on each side of the stack.
8. **Weather Hood for purge air system**: For US built systems there is not a separate weather hood for the purge air system. See item 7.
9. **Fail Safe Shutters D-SK 280 MA**: The shutter will close during a loss of power or loss of purge air. This will prevent damage from the stack gas to the opacity system. The shutter may also be used for personnel protection on over pressure stacks.
10. **Fail Safe Shutter Control Electronics D-SK 290 AE**: This is the sensor electronics for the purge air flow sensor and has the battery pack to run the shutter motor, and has control functions to open and close the shutter when instructed.

3.5.1 Configuration options for stack and control room displays

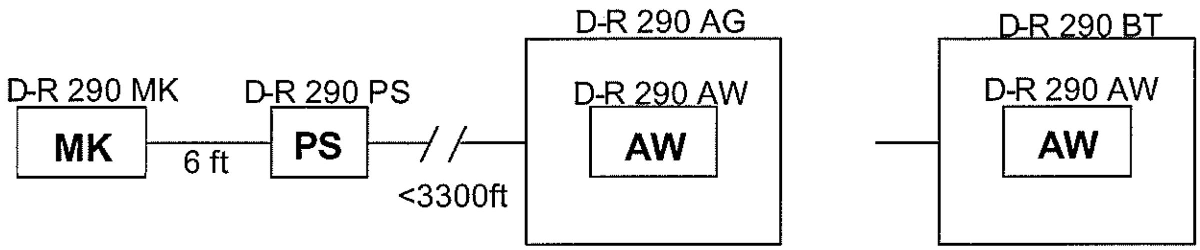
Since the D-R 290 system can be used with or without a D-R 290 AZ and there can be different housings used (primarily for the D-R 290 AW) it can be somewhat confusing. The diagrams below illustrate the different configurations for the D-R 290 AW evaluation unit and the D-R 290 AZ stack display.



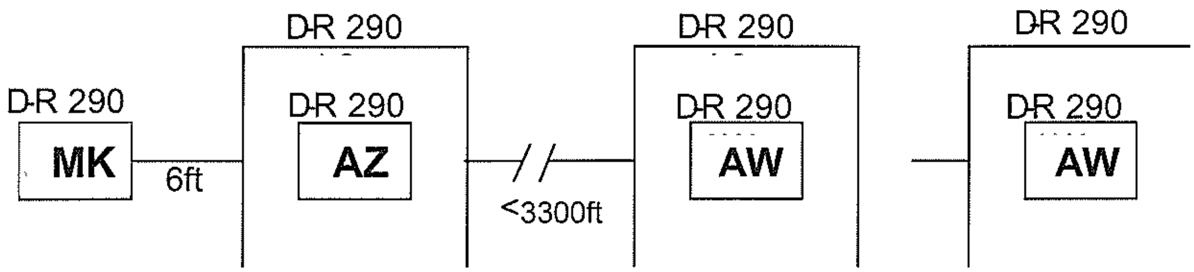
Transceiver connected directly to the D-R 290 AW located at transceiver location. The D-R 290 AW electronic insert is mounted in the D-R 290 AG wall mount housing.



Similar to above except an extension cable is placed between transceiver and D-R 290 AW.



The transceiver is now powered from the D-R 290 PS power supply located at the monitor location. Now the D-R 290 AW can be located up to 3300 feet (1000m) from the transceiver. A 2 pair cable is used to transmit the data over the RS 422 interface. Since the D-R 290 AW unit can be mounted indoors now, a panel mount housing, D-R 290 BT, can be used. More information is given on these different housings in the installation section of this manual.



The above diagram shows the recommended mounting arrangement. The D-R 290 AZ is used in the D-R 290 AG housing at the transceiver location. Calibration functions and filter audits can be ran from this location using the D-R 290 AZ. The remotely mounted D-R 290 AW can be mounted in the wall mount or panel mount housing with panel mount in a 19" rack being the most common.

4. Selection of the Measuring Location

The measuring location should be positioned in a straight section of the duct, as far from upstream or downstream turns as possible. 40 CFR part 60, Appendix B, Performance Specification 1 gives guidelines for the mounting location. If necessary, check with local authorities to insure a proper installation location is selected. Try to install the equipment in a location that will allow for service and is free from vibration and with the best ambient conditions possible.

5. Installation

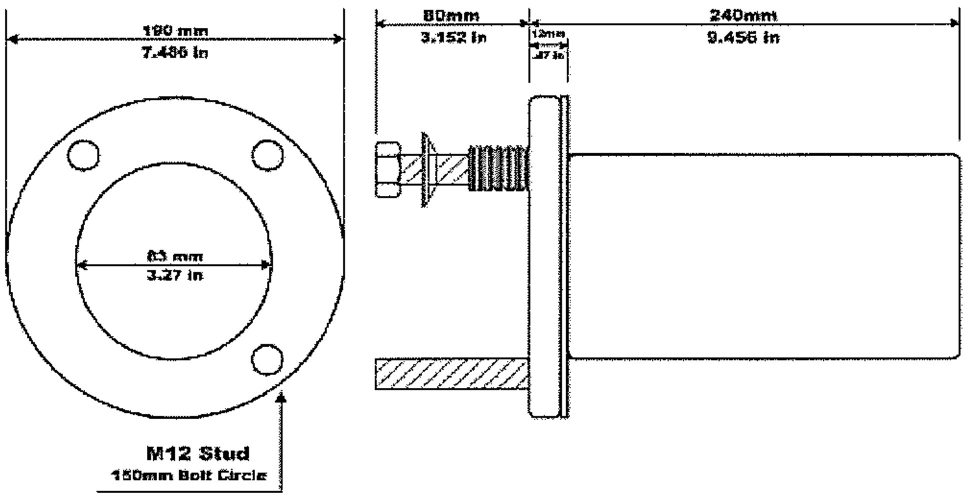
5.1 Flange Installation

For installation of the optic head and the reflector, installation flanges must be installed. For thickly insulated stacks and brick-lined chimneys, the tube must be lengthened accordingly. The flanges are available in carbon steel as a standard and stainless steel as an option. Normally these flanges are welded to the stack but for brick or concrete stacks a plate may be welded to the flange and then bolted to the stack. If existing flanges are available, Durag, Inc. can supply adapter flanges in most cases.

The pipes and installation flanges **must** be precisely aligned to allow the light beam to pass through the flanges. For short path lengths, a pipe may be inserted through the flanges to help align the flanges. For longer path lengths an alignment tool (D-R 280-70) is available from DURAG, Inc. The flange alignment must be within ± 1° of accuracy of centerline. The red dot on the installation flange must be on the top. Often it is recommended that the flange tube protrudes into the stack about 1 inch from the stack wall. This is done so that if rain or condensate runs down the stack wall it should run around the flange tube and not into the flange tube. There are many installations where this is not a concern and the flange tube is flush with the stack wall with no problems.

If the walls are thin, gusset plates must be installed for reinforcement. For stacks with flue gas temperatures of over 482°F (250°C), insulation should be installed. Use of fail-safe shutters is also recommended. If there is an existing set of flanges, DURAG, Inc., can make adapter flanges to mate to these flanges.

If the flange tube length is modified, please note this distance because it will be required when setting up the operating parameters of the system. When the flanges have been installed, measure the flange to flange distance so the monitor can be set up to this same distance on a clear path to get an accurate zero reading.

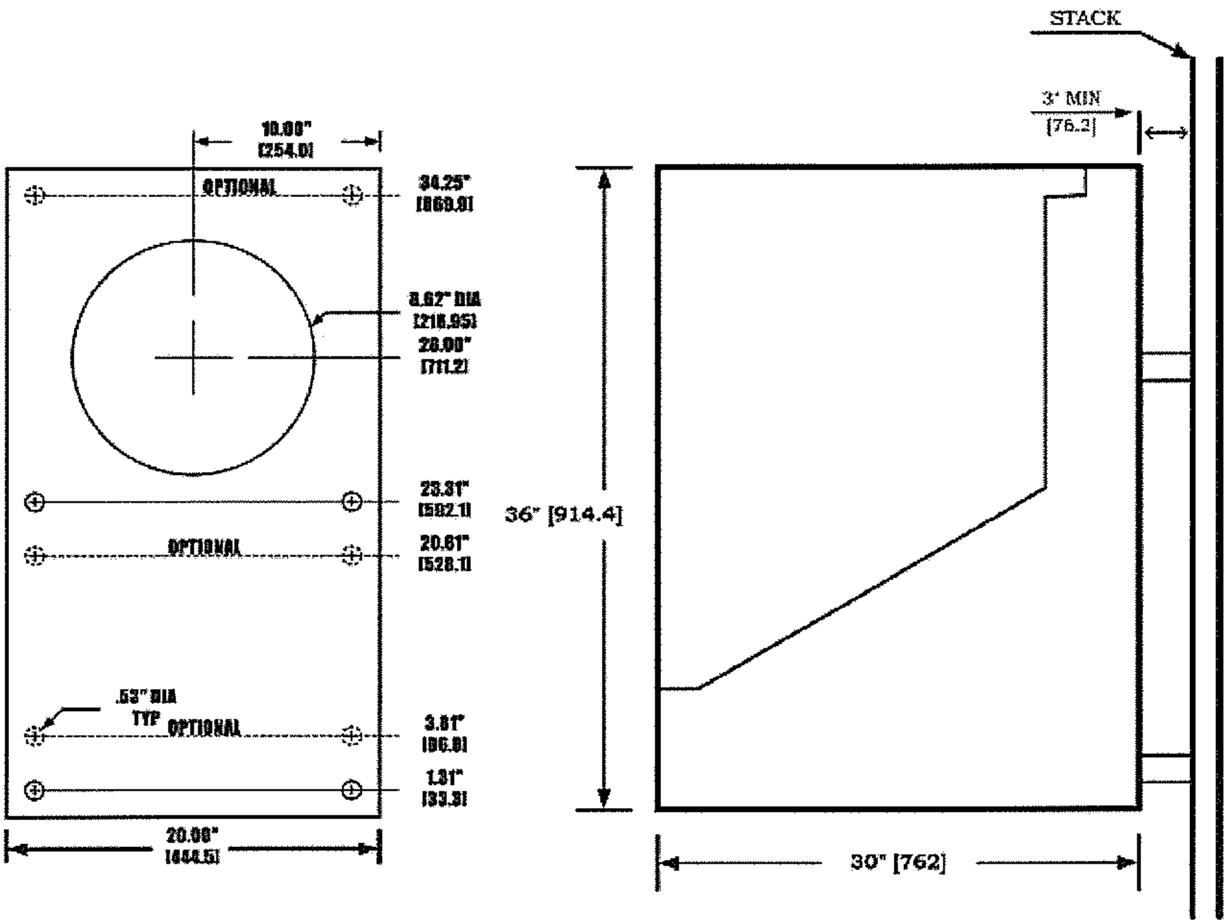


(Fig. 5.1) D-R 280-10E installation flange for D-R 290 Opacity Monitor

Important Note: The red dot on the installation flange must be on top.

5.2 Blower Panel and Weather Hood Installation

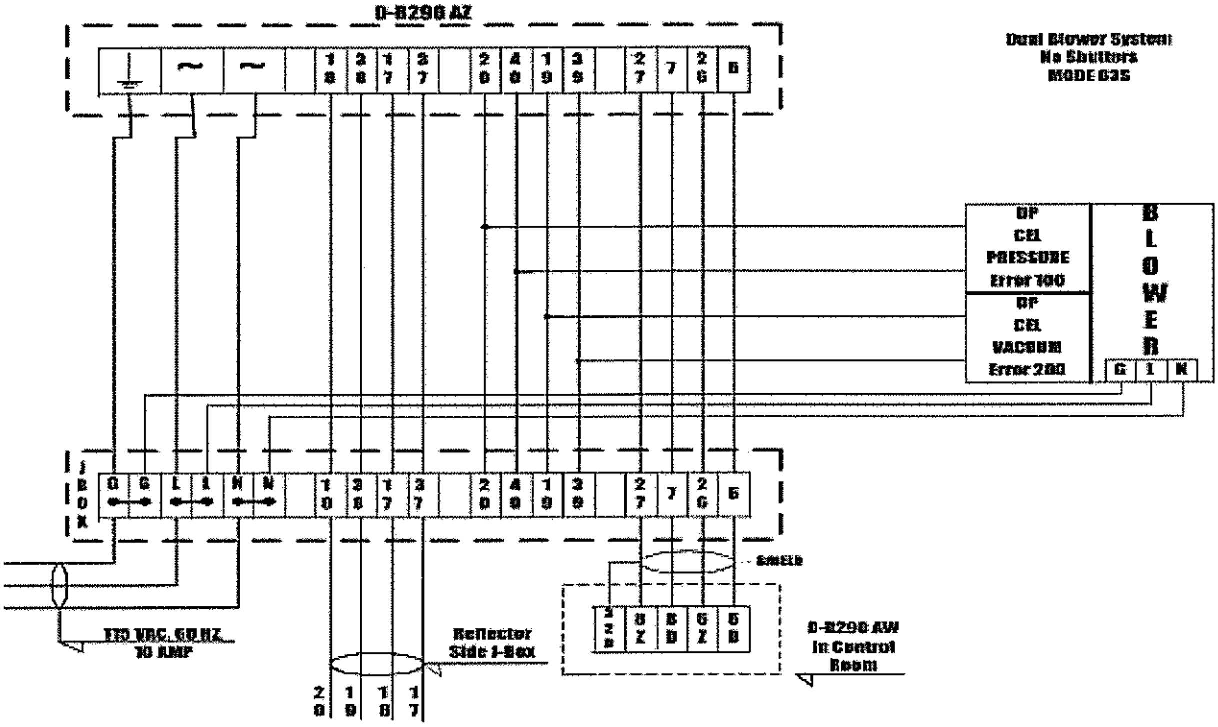
In outdoor applications the purge air blower, the stack display unit (D-R 290 AZ), the shutter control electronics (D-SK AE) if used, and a small junction box for power terminations are mounted to the weather hood. The weather hood is a fiberglass box with a cover that hinges. After the stack flanges are installed on the stack, the weather hood is then mounted to the stack. It is recommended to leave a 3 to 4 inch gap between the back of the weather hood and the stack. This will allow for airflow behind the weather hood and help minimize the amount of radiant heat from the stack to the box. If the stack is well insulated this should not be an issue. This box will also serve as a weather hood for the transceiver and reflector. Typically this box is mounted with stand-offs from the stack or by a framework that the box sits into and this framework is mounted to the stack. The weather hood with all components will weigh 100 to 150 pounds depending upon the size of the blower and optional equipment so care should be used when attaching this weather hood and associated mounting hardware. It is important to note that the transceiver side weather hood will be different from the reflector side weather hood. The D-R 290 AZ (stack display) will be mounted in the transceiver side weather hood and the J-Box will be different. There will normally be a sticker labeling this on the back of the weather hood but in the event this gets removed, look inside for the D-R 290 AZ.



(Fig. 5.2) Weather hood dimensions

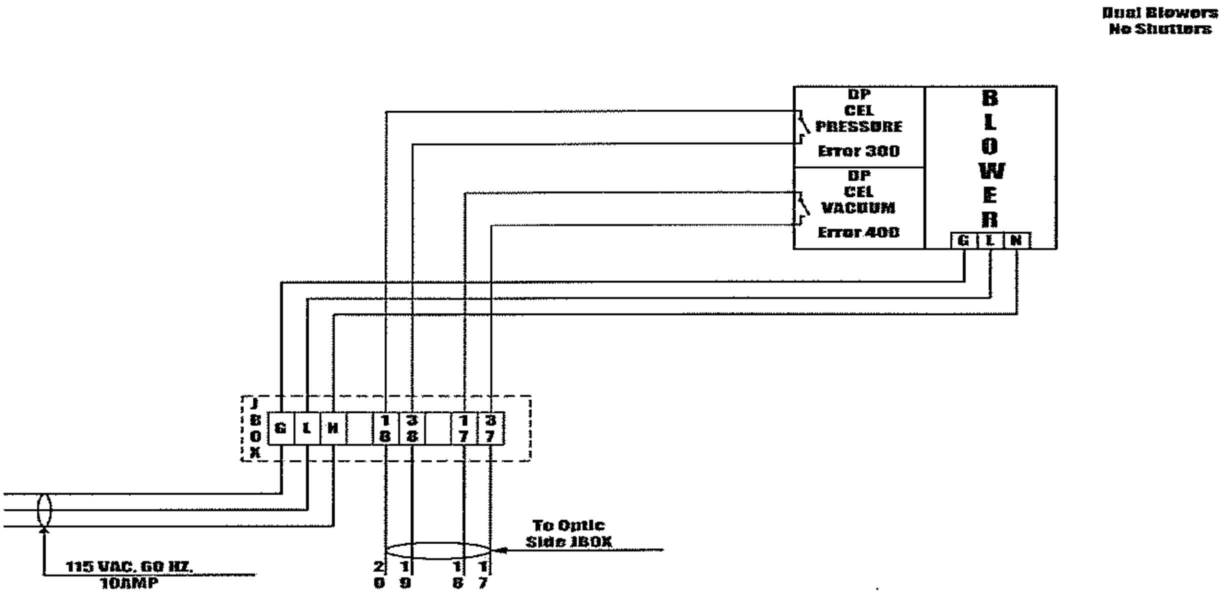
5.2.1 Weather Hood and Blower Panel Electrical Installation

Normally Durag, Inc. will pre-wire as much as possible to minimize the number of field terminations. Typically a J-Box will be installed in the weather hood or on the blower panel and the various components will be pre-wired to this J-Box and the customer will make their terminations to a terminal strip in the J-Box. Due to all the different configurations of the blower panel or weather hood (single blower, dual blower, one, two, or no shutters, with or without D-R 290 AZ) it is not practical to show all the wiring diagrams. The specific wiring diagrams will be included with the monitor and can be sent out prior to installation. An example of a typical wiring diagram for the transceiver side and reflector side weather hood is given below.



OPTIC HEAD SIDE

(Fig. 5.3) Transceiver side interconnect wiring, typical



REFLECTOR SIDE

(Fig. 5.4) Reflector side interconnect wiring, typical

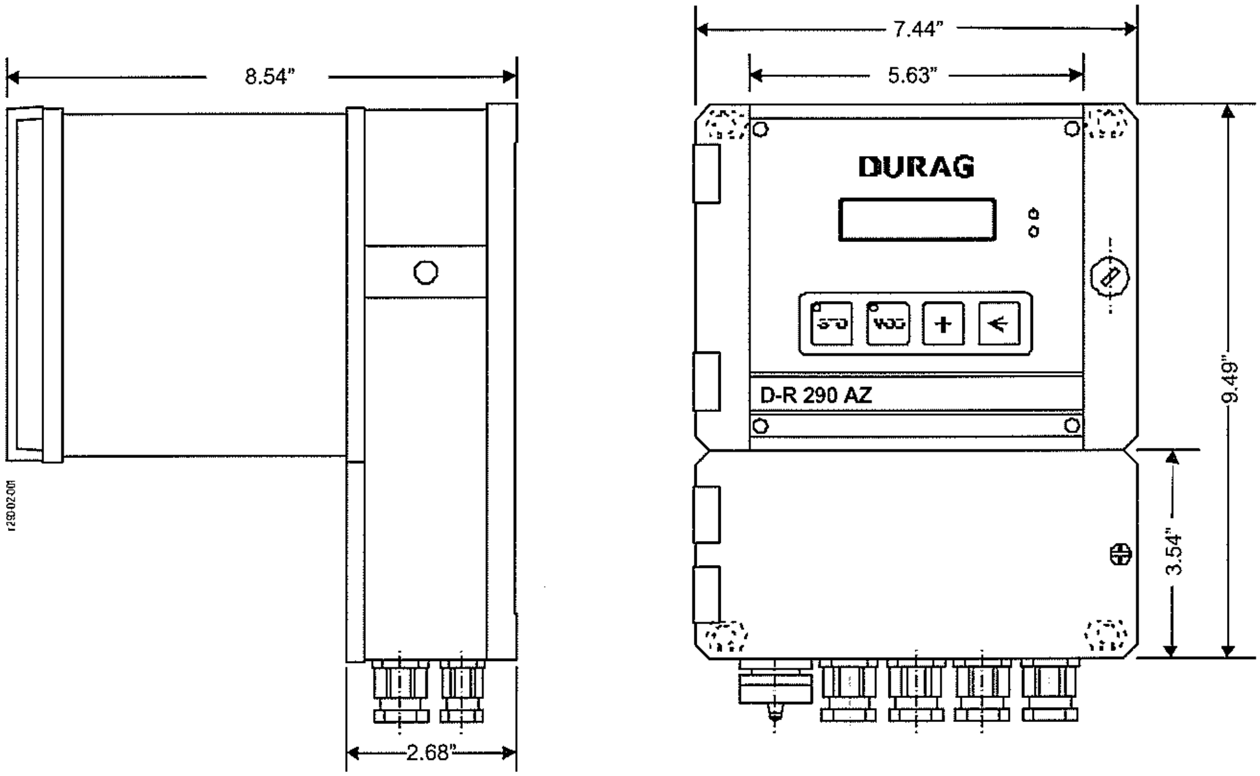
5.3 D-R 290 AZG Stack-Mounted Display Module

The D-R 290 AZG consists of two components. The electronic module is the D-R 290 AZ and the housing with electrical terminations is the D-R 290 AG. Since these components are almost always used together, the term D-R 290 AZG is used to refer to this housing with the display electronics.

The D-R 290 AZG is mounted on the stack at the measuring location and is usually mounted in the weather hood. The D-R 290 AG housing has an enclosure rating of IP 65 (corresponding to NEMA 4X) in a watertight aluminum housing. The cable from the transceiver that plugs into the D-R 290 AZG is 6 feet long so the D-R 290 AZG must be mounted near the transceiver.

The buttons and Liquid Crystal (LC) display on the front panel are visible through a transparent cover that swings opens to the left. The terminal connections are towards the bottom of the housing with a separate access cover from the LC display portion of the housing. Cord grip (Pg) fittings are provided for electrical connections and one connector for the connection to the transceiver. Normally only 4 wires for the RS 422 interface will need to be connected to this unit to communicate with the D-R 290 AW. The power, shutter control, and DP Cells will be pre-wired by DURAG. More information regarding the electrical interface is given in the electrical installation section.

The D-R 290 AG housing is normally pre-install in the weather hood but if it must be removed or installed, open the transparent cover, and then remove the electronics insert from the housing, use a screwdriver to release the latch on the right hand side and swing this portion open, and then remove the mounting bolts.



(Fig. 5.5) D-R 290 AG wall mount housing dimensions

Color: Housing body and enclosure are blue RAL 5017.
Ambient temperature: -40°F to +200°F (-40°C to +100°C).
Mounting hole diameter 6,5 mm, spacing 166 x 220 mm.

5.3.1 Electrical Installation, D-R 290 AZG Stack-Mounted Display Module

Normally the D-R 290 AZ is pre-wired and the customer only needs to connect the 4 wires for the RS 422 link to the D-R 290 AW in the shelter.

Stack Display D-R 290 AZ		D-R 290 AZ must be used with D-R 290 AW (evaluation unit)		
Terminal	**Name**	**Function**		
PE	Ground			
N	Neutral	Power supply		
L	Line	90 - 264 Volt		
40	Digital Input 1	Error 100		
20		Blower fail transceiver side		
39	Digital Input 2	Error 200		
19		Purge filter plugged transceiver side		
38	Digital Input 3	Error 300		
18		Blower fail reflector side		
37	Digital Input 4	Error 400		
17		Purge filter plugged reflector side		
36	Digital Input 5	Error 500		
16		Shutter (Optional) fail transceiver side		
35	Digital Input 6	Error 600		
15		Shutter (Optional) fail reflector side		
34	Relay 6	NO	Measuring relay, energized when measuring,	
14		Common	Fault, in cal, or power off	
33		NC	Relay is de-energized	
13	Relay 5	NO		
32		Common	Warning energizes relay	
12		NC		
31	Relay 1	Status signal when shutters are used		
11		For D-SK 1		
30	Relay 2	Status signal when shutters are used		
10		For D-SK 2		
29	Relay 3	Used to signal shutter controller	To D-SK AE 1 pin 16	
9		D-SK AE 1	To D-SK AE 1 pin 17	
28	Relay 4	Used to signal shutter controller	To D-SK AE 2 pin 16	
8		D-SK AE 2	To D-SK AE 2 pin 17	
27	RS 422	To D-R 290 AW plug 1, terminal **8Z**		
7		To D-R 290 AW plug 1, terminal **8D**		
26	Link	To D-R 290 AW plug 1, terminal **6Z**		
6		To D-R 290 AW plug 1, terminal **6D**		
4	Analog out 2	plus	4 – 20 ma, 2nd termination	Current signal on the
5		minus		D-R 290 AZ analog
24	Analog out 2	plus	4 – 20 ma, 1st termination	Outputs will be the same
25		minus		As on the D-R 290 AW
2	Analog out 1	plus	4 – 20 ma, 2nd termination	Analog outputs
3		minus		Normally these are not connected
22	Analog out 1	plus	[illegible]	Since the D-R 290 AZ is

23		minus		
1		PE (Ground)		

(Table 5.6) D-R 290 AZ stack display I/O

5.4 Transceiver and Reflector Installation

The transceiver consists of the optical portion in the blue housing and the black purge air flange. The reflector consists of the reflector element in the blue housing and the black purge air flange. The purge air flange is identical for the transceiver and reflector. The purge air flange is connected to the transceiver or reflector by 2 hinge pin bolts. If there is stack gas coming from the stack flanges due to an overpressure stack, the optics of the transceiver and reflector should be protected. The best way to do this is to connect the air hose to the purge air fan and turn on the blower. Make sure the 12 spring washers are on each stud and the black rubber sealing collar is slipped over the flange. Then the purge air flange can be slipped onto the 3 studs on the flange. Next put the spherical washers on each stud and then the lock nut. Tighten the lock nuts until there is some compression of the spring washers. If this is not tightened enough, the system will not be help in position. f tightened too much, the spring will be collapsed and there will not be any vertical or horizontal adjustment to the transceiver or reflector.

Figure 5.7 shows a typical installation:

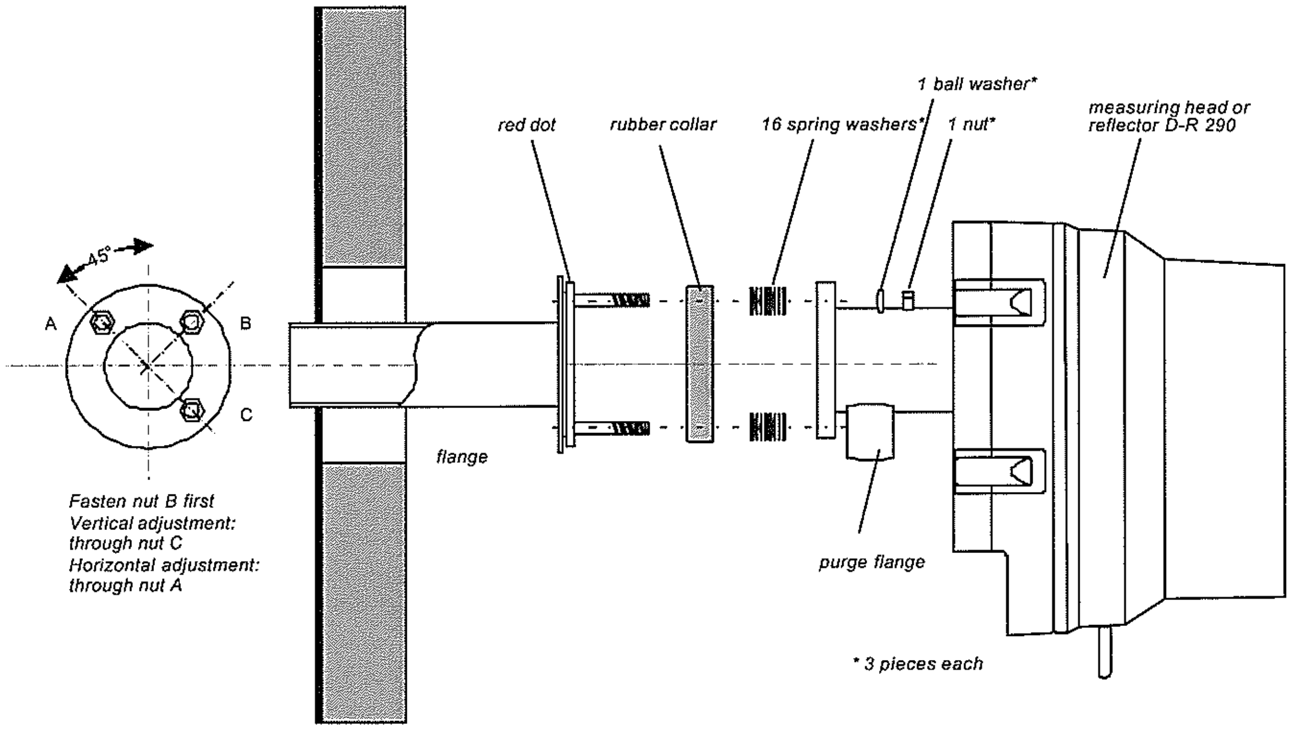
1.) 12 spring washers (the 16 washers on drawing is from old flange design)

2.) rubber sealing collar

3.) purge air flange of instrument

4.) spherical washer

5.) M12self-lockingnut



(Fig. 5.7) Mounting monitor on the installation flange

5.4.1 Transceiver and reflector alignment and focus

The transceiver and reflector are aligned to each other by adjusting the 3 nuts on each flange. However this can not be done until **all** the system components have been connected and the opacity system is running. This is because the alignment sight on the side of the transceiver uses the light from the LED to generate the image and the LED is not operating until the system is all powered. Once the system is powered and the initial daily calibration (that starts automatically upon power-up) is complete, the system can be aligned.

To align the transceiver, look through the alignment sight on the side of the transceiver housing. Make sure the reflector is closed on the reflector side. Then by adjusting the nuts on the stack flange of the transceiver side as shown in the previous figure, move the transceiver in the horizontal and vertical directions until the reflector image is centered in the "bulls eye" of the alignment sight. Please note that as the transceiver is moved horizontally, the image in the alignment site will move vertically. On longer range systems the image in the alignment sight may not appear very bright. It may be helpful to cup your hands around the eye piece of the alignment site to block the ambient light when aligning the transceiver. The adjustment nuts should compress the spring washers to the point that the transceiver (or reflector) is stable. The spring washers should not be completely compressed, then there would be no room for further adjust the alignment.

The focus adjustment was set at the factory and should not need to be changed unless the system is being installed at a different path length. The focus only needs to be adjusted for flange to flange path lengths under 88 inches (Reflector 1 systems). For longer path lengths, the focus knob will need to be turned CCW as far as possible to achieve the proper focus. To adjust the focus, loosen the metal thumb screw and then move the objective lens by turning the thumb screw with the plastic knob. Adjust the focus until the image in the alignment sight is sharp. When finished, tighten the metal optics screw again to secure this setting.

To align the reflector, first release the latches and swing the reflector open from the purge air flange. Sight down the inner tube of the purge air flange and look at the light from the transceiver. Adjust the reflector purge air flange by with nuts on the stack flange until this tube is aligned and pointing at the transceiver. The reflector is auto collimating so the reflector alignment is usually not as critical as the transceiver alignment. This alignment procedure for the reflector requires a judgment call for when the inner tube is aligned. If the end user is not comfortable with this, a purge air flange alignment tool is available from DURAG, Inc. Once the purge air flange is aligned, the reflector will automatically be aligned when the reflector is closed and latched against the purge air flange. Then go back to the transceiver side and verify the transceiver alignment.

5.4.2 Transceiver and reflector electrical installation

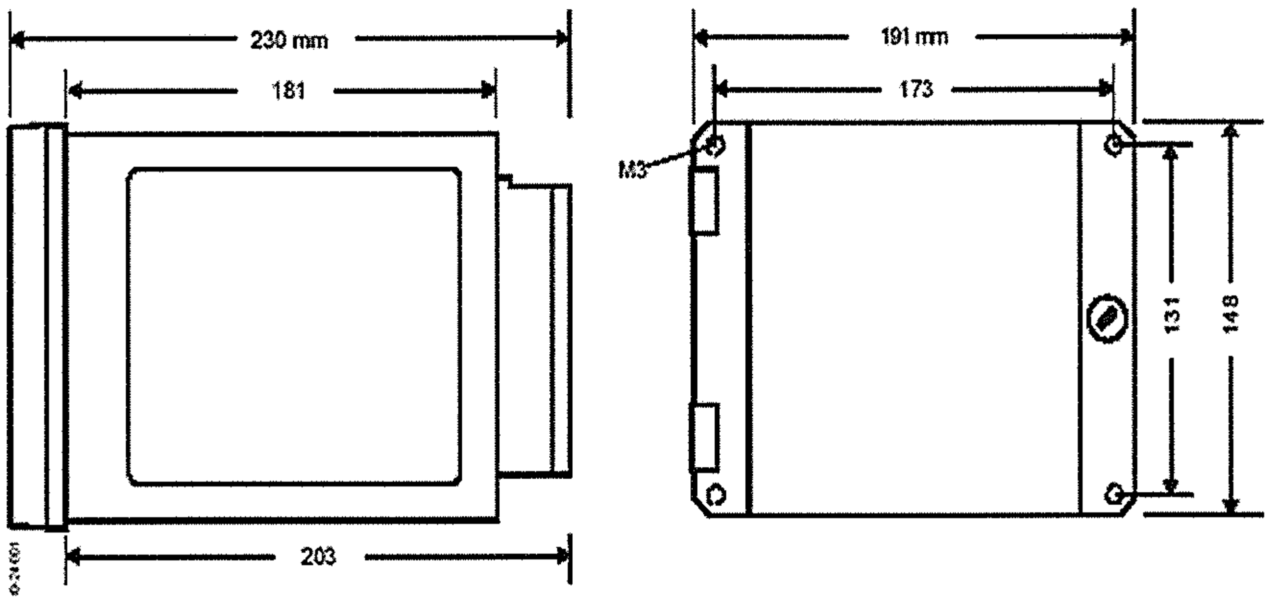
The reflector is a passive component and there are no electrical connections. The transceiver has a 6 foot cable with a 10 pin keyed bayonet style connector. This connector will be plugged into the D-R 290 AZG (Stack Display) or will be plugged into the D-R 290 AW on systems without the D-R 290 AZ. A diagram of the cable connections and function is shown below.

Connection to the transceiver D-R 290 MK					
Evaluation unit D-R 290 AW		Transceiver Cable connection			
Plug	Contact	Pin	Cable Nr	Pin X4	Function
Plug 1	32 D Z	Housing	Ground		Ground
Plug 1	12 D Z	B	1	1	+ 15 Volt
Plug 1	32 D Z	D	2	2	GND
Plug 1	14 D Z	C	3	3	- 15 Volt
Plug 1	2 D Z	A	4	4	+ 5 Volt
Plug 1	32 D Z	E	green / yellow	5	PE
Plug 1	32 D Z	F	6	6	GND
Plug 1	8 D	J	7	7	RS 422 < –
Plug 1	8 Z	H	8	8	RS 422 < –
Plug 1	6 D	G	9	9	RS 422 –>
Plug 1	6 Z	M	10	10	RS 422 –>

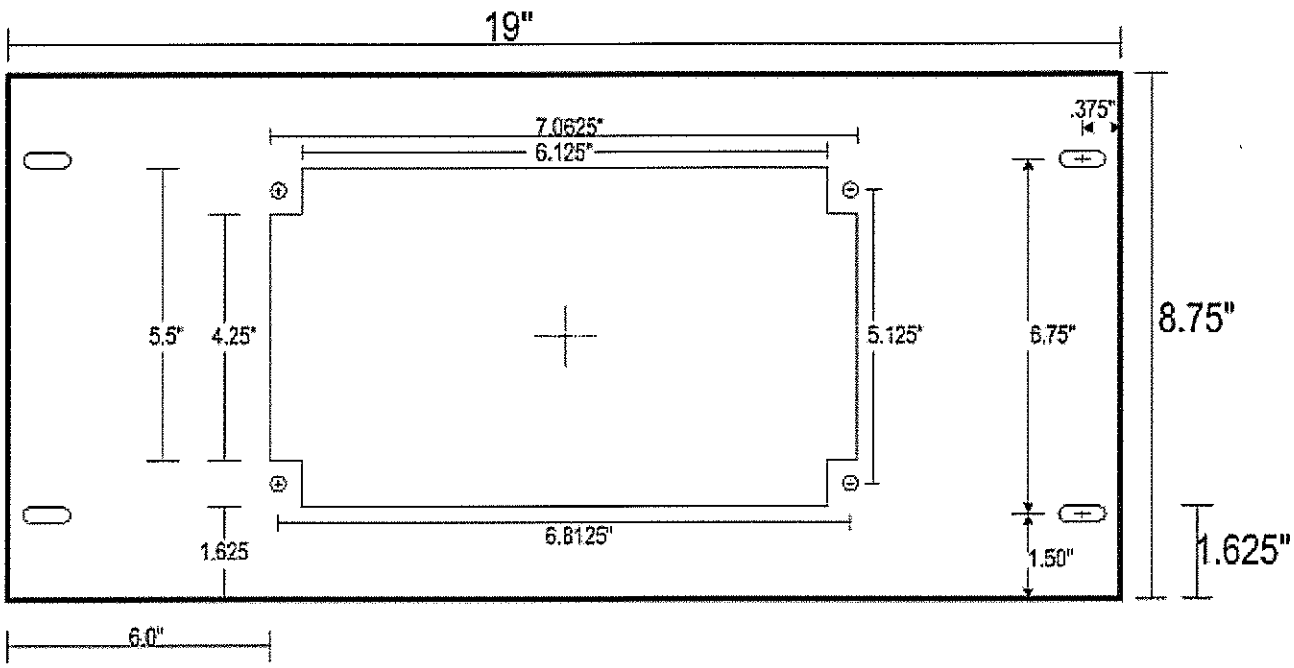
5.5 D-R 290 AW Evaluation Unit Installation

The D-R 290 AW is typically panel mounted or placed in a 19" rack. The D-R 290 AW electronic insert is the same as the D-R 290 AZ electronic insert except for the software. This electronic insert is then placed into a panel mount housing that has terminal strips on the back for electrical connections. This panel housing has the part number D-R 290 BT. This is usually mounted in a 19 inch rack but this could be mounted in any panel. A ¼ inch thick aluminum plate with a cut out for the D-R 290 BT is available for rack mounting. This plate has the part number D-R 290 AW19 Plate.

It is possible to operate the opacity system with only the D-R 290 AW without using the D-R 290 AZ. In this case the D-R 290 AW electronic insert will be mounted in the D-R 290 AG wall mount housing and this assembly will be called the D-R 290 AWG. The cable of the transceiver will be plugged directly into the D-R 290 AG wall mount housing. An extension cable is available to increase the distance between the transceiver and the D-R 290 AWG. The maximum distance of this extension cable is 65 feet (20 meters) and the part number is D-R 290 LTx where x is the length in meters. DURAG, Inc. recommends using the D-R 290 AZ in most applications and the additional features are well worth the small cost. However there are applications such as when the data logger is located near the opacity monitor where this type of installation would make sense.



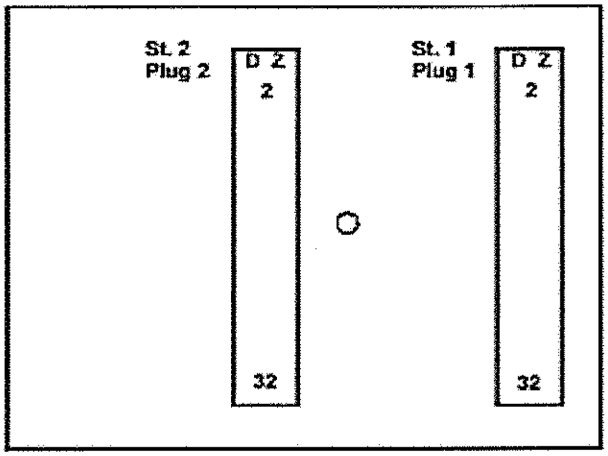
(Fig. 5.8) D-R 290 BT dimensional diagram



(Fig. 5.9) D-R 290 AW19 dimensional diagram

5.5.1 D-R 290 AW Electrical Connection when used with D-R 290 AZ

Since the in the majority of the installations the D-R 290 AW will be used with the D-R 290 AZ stack display The D-R 290 AW will also be mounted in the control room or shelter and placed in the D-R 290 BT housing. The electrical connections when the D-R 290 AW is used without the D-R 290 AZ will be described in the next section. Electrical connections for the D-R 290 AW control panel are made using the two terminal strips on the back of the D-R 290 BT. These 2 terminal strips are labeled Plug 1 and Plug 2. When you view the back of the D-R 290 BT Plug 1 will be on you right and Plug 2 on the left. The rows of terminals are numbered 2, 4, 6,...32 from top to bottom. The column of terminals on the left is D and the column on the right of the plug is Z. When you see a terminal listed as 32 DZ, the DZ together indicates that the D and Z terminals on row 30 are internally bridged together. **Warning:** These 2 plugs appear identical so one must be careful not to get these two plugs confused. Power is applied on Plug 2 (terminals 28 DZ, 30 DZ, and 32DZ). If you apply power to these terminals on Plug 1 you will probably blow up one of the analog outputs.



(Fig. 5.10) D-R 290 BT terminal connectors

Evaluation Unit D-R 290 AW		For use when D-R 290 AW is connected to D-R 290 AZ							
Plug	Terminal	Name	Function						
Plug 2	32 D Z	Ground	Power supply 90 - 264 Volt						
Plug 2	28 D Z	Neutral							
Plug 2	30 D Z	Line							
Plug 2	2 D	Digital Input 1	Programming Enable						
Plug 2	2 Z								
Plug 2	4 D	Digital Input 2	Start Cal Cycle						
Plug 2	4 Z								
Plug 2	6 D	Digital Input 3	Set up Mode 0x-5x	External Error 002					
Plug 2	6 Z		Set up Mode 6x	Zero Check					
Plug 2	8 D	Digital Input 4	Set up Mode 0x-5x	Range 2 for Analog Out 1					
Plug 2	8 Z		Set up Mode 6x	Window Check					
Plug 2	10 D	Digital Input 5	Set up Mode 0x-5x	Range 2 for Analog Out 2					
Plug 2	10 Z		Set up Mode 6x	Upscale Calibration Check					
Plug 2	12 D	Digital Input 6	Set up Mode 0x-5x	External Error 003					
Plug 2	12 Z		Set up Mode 6x	Display Stack Factor					
Relays 1-4 Function determined by set-up mode			0x	1x	2x	3x	4x	5x	6x
Plug 2	20 D	Relay 1	None	Limit 1 Analog1	Limit 1 Analog2	Limit 1 Analog1	Zero Check	Zero Check	Zero Check
Plug 2	20 Z								
Plug 2	22 D	Relay 2	None	Limit 2 Analog1	Limit 2 Analog2	Limit 2 Analog2	Window check	Window check	Window check
Plug 2	22 Z								
Plug 2	24 D	Relay 3	D-SK 1	D-SK 1	D-SK 1	D-SK 1	Upscale check	Upscale check	Upscale check
Plug 2	24 Z								
Plug 2	26 D	Relay 4	D-SK 2	D-SK 2	D-SK 2	D-SK 2	Stack Factor	D-SK 1	Stack Factor
Plug 2	26 Z								
Plug 2	16 Z	Relay 5	NO	Warning energizes relay					
Plug 2	18 D		Common						
Plug 2	18 Z		NC						
Plug 2	14 D	Relay 6	NO	Measuring relay, energized when measuring (If in Fault, in cal, or power off Relay is de-energized)					
Plug 2	14 Z		Common						
Plug 2	16 D		NC						
Plug 1	6D	RS 422 Communication	To D-R 290 AZG terminal 6						
Plug 1	6Z		To D-R 290 AZG terminal 26						
Plug 1	8D		To D-R 290 AZG terminal 7						
Plug 1	8Z		To D-R 290 AZG terminal 27						
Plug 1	24 D Z	Analog out 1	plus	4 – 20 ma, 2^{nd} termination	Data on analog Outputs (opacity, optical density, calibration results) is also Function of the Set-up Mode See table 6.1				
Plug 1	26 D Z		minus	Normally not connected					
Plug 1	28 D Z	Analog out 1	plus	4 – 20 ma, 1^{st} termination					
Plug 1	30 D Z		minus						
Plug 1	16 D Z	Analog out 2	plus	4 – 20 ma, 2^{nd} termination					
Plug 1	18 D Z		minus	Normally not connected					
Plug 1	20 D Z	Analog out 2	plus	4 – 20 ma, 1^{st} termination					
Plug 1	22 D Z		minus						
Plug 1	32 D Z		PE shielding for RS 422						

(Table 5.11) D-R 290 AW mounted in D-R 290 BT housing, terminal connections

5.5.2 D-R 290 AW Stand Alone Electrical Connection (No D-R 290 AZ)

Evaluation Unit D-R 290 AW		Only for Use with D-R 290 AW in wall mount housing No D-R 290 AZ is used						
Terminal	**Name**	**Function**						
PE	Ground	Power supply 90 - 264 Volt						
N	Neutral							
L	Line							
40	Digital Input 1	Programming Enable						
20								
39	Digital Input 2	Start Cal Cycle						
19								
38	Digital Input 3	Set up Mode 0x-5x	External Error 002					
18		Set up Mode 6x	Zero Check					
37	Digital Input 4	Set up Mode 0x-5x	Range 2 for Analog Out 1					
17		Set up Mode 6x	Window Check					
36	Digital Input 5	Set up Mode 0x-5x	Range 2 for Analog Out 2					
16		Set up Mode 6x	Upscale Calibration Check					
35	Digital Input 6	Set up Mode 0x-5x	External Error 003					
15		Set up Mode 6x	Display Stack Factor					
Relays 1-4 Function Determined by set-up mode		0x	1x	2x	3x	4x	5x	6x
31	Relay 1	None	Limit 1	Limit 1	Limit 1	Zero	Zero	Zero
11			Analog1	Analog2	Analog1	Check	Check	Check
30	Relay 2	None	Limit 2	Limit 2	Limit 2	Window	Window	Window
10			Analog1	Analog2	Analog2	check	check	check
29	Relay 3	D-SK 1	D-SK 1	D-SK 1	D-SK 1	Upscale	Upscale	Upscale
9						check	check	check
28	Relay 4	D-SK 2	D-SK 2	D-SK 2	D-SK 2	Stack	D-SK 1	Stack
8						Factor		Factor
13	Relay 5	NO	Warning energizes relay					
32		Common						
12		NC						
34	Relay 6	NO	Measuring relay, energized when measuring, Fault, in cal, or power off Relay is de-energized					
14		Common						
33		NC						
27	RS 422 Link	**Note:** When using D-R 290 AW without D-R 290 AZ Terminals 6 and7 must be connected with a jumper and Terminals 26 and27 must be connected with a jumper to Complete the RS 422 communication to the transceiver						
7								
26								
6								
2	Analog out 1	plus	4 – 20 ma, 2nd termination	Data on analog Outputs (opacity, optical density, calibration results) is also Function of the Set-up Mode See table 6.1				
3		minus	Normally not connected					
22	Analog out 1	plus	4 – 20 ma, 1st termination					
23		minus						
4	Analog out 2	plus	4 – 20 ma, 2nd termination					
5		minus	Normally not connected					
24	Analog out 2	plus	4 – 20 ma, 1st termination					
25		minus						
1		PE (Ground)						

(Table 5.12) D-R 290 AW mounted in D-R 290 AG housing, terminal connections (No D-R 290 AZ)

6. Operation

Before the D-R 290 opacity system will function, the electrical connections need to be made at the transceiver location (blowers, transceiver, stack display) and the D-R 290 AW will need to at a minimum have power and the RS 422 communication lines terminated. In a typical installation with the D-R 290 AZ stack display, the D-R 290 AW evaluation unit talks to the D-R 290 AZ, the D-R 290 AZ talks to the D-R 290 MK (transceiver) and the D-R 290 MK talks to the D-R 290 AW. In a system without a D-R 290 AZ, the D-R 290 AW and the D-R 290 MK talk back and forth to each other but the D-R 290 AW is the "brains". This is the flow of data in the communication loop. If any piece of the equipment is not powered or there is a wiring error in the 4 wires for the RS 422 there will be a communication error. This will show up on the display panel(s) as an "Error 000". Without communication, the transceiver does not know what to do and will idle and not function. Since in this error condition the transceiver is not functioning, it is not possible to align the transceiver or really do much of anything. The first step is to make sure communication is established, then the transceiver can be aligned or system parameters viewed or changed.

6.1 Operation of the D-R 290 AW evaluation unit

The D-R 290 is controlled using the four buttons and the LCD on the front panel of the evaluation unit. These buttons are membrane switches that are polled about every second. You may have to hold the button in for about a second and then release to activate the desired function. A description of the buttons is given below.

6.1.1 Parameters

There are a number of parameters that the user can set in the D-R 290 evaluation unit such as measuring range, alarm points, integration time, etc. Below is a list of these parameters in the same order as they appear when you scroll through the display as well as a description. These parameters are set by Durag before the system is shipped and normally should not need to be changed.

There are many different data logging systems and many desired features from an opacity system. DURAG has tried to incorporate as much flexibility as possible with a fixed amount of I/O. Many of the features and options will not be used in most cases. The description of the parameters may seem over complicated at first but when you look at just the features you are using, the system should appear much easier to use.

When the parameters are viewed from the D-R 290 AW or the D-R 290 AZ, the system is still measuring and the data on the analog output is still valid until the Filter Audit parameter is reached. The parameters can be scrolled through up to Limit Value 2. At this point the MOD Key can be pressed again and you can step out of the display parameters mode without affecting the measured opacity data on the analog outputs. The last 5 parameters, Filter Audit and the 4 calibration phases, will cause these tests to be performed and the data on the analog outputs and relays will respond accordingly.

6.1.1.1 SET-UP MODE

The set-up mode determines how the systems inputs and outputs (I/O) functions. The data on the analog outputs (opacity or optical density), the function of the digital inputs and the relay outputs is determined by the 2 digit number for the set-up mode.

Opacity: = [OP%], Extinction: = [OD] calibrated in mg/m³.

Set-up Mode I/O Function

Display 1s digit	***Output - 1 Measuring in***	***Output - 2 Measuring in***	***Control cycle on***	
X 0 S	OD	OD	Output-1	
X 1 S	OP%	OD	Output-1	
X 2 S	OD	OP%	Output-1	
X 3 S	OP%	OP%	Output-1	
X 4 S	OD	OD	Output-1 + Output-2	
X 5 S	OP%	OD	Output-1 + Output-2	
X 6 S	OD	OP%	Output-1 + Output-2	
X 7 S	OP%	OP%	Output-1 + Output-2	
Display 10s digit	***Relay 1 Function***	***Relay 2 Function***	***Relay 3 Function***	***Relay 4 Function***
0 X S	X	X	D-SK 1	D-SK 2
1 X S	Limit 1, output 1	Limit 2, output 1	D-SK 1	D-SK 2
2 X S	Limit 1, output 2	Limit 2, output 2	D-SK 1	D-SK 2
3 X S	Limit 1, output 1	Limit 2, output 2	D-SK 1	D-SK 2
4 X S	Zero Check	Window check	Upscale check	Stack Factor
5 X S	Zero Check	Window check	Upscale check	D-SK
6 X S	Zero Check	Window check	Upscale check	Stack Factor

<table>
<tr><th>Display 10s digit</th><th>Digital Input 1</th><th>Digital Input 2</th><th>Digital Input 3</th><th>Digital Input 4</th><th>Digital Input 5</th><th>Digital Input 6</th></tr>
<tr><td>0 X S</td><td rowspan="7">Enable Programming (close to change parameters)</td><td rowspan="7">Start Cal Closed=no cal Open=cal by timer Upon opening =start cal</td><td rowspan="6">External Error 002 (Shutter, DP Cell)</td><td rowspan="6">Range 2 Output 1 Close to change analog output 1 to range 2</td><td rowspan="6">Range 2 Output 2 Close to change analog output 2 to range 2</td><td rowspan="6">External Error 003 (Shutter, DP Cell)</td></tr>
<tr><td>1 X S</td></tr>
<tr><td>2 X S</td></tr>
<tr><td>3 X S</td></tr>
<tr><td>4 X S</td></tr>
<tr><td>5 X S</td></tr>
<tr><td>6 X S</td><td>Zero check</td><td>Window</td><td>Upscale</td><td>Stack factor</td></tr>
</table>

(Table 6.1) How set-up mode changes I/O

The ones digit will control the data on the analog outputs. Normally this will be a 3 or a 7 for opacity on both analog outputs. The difference between 3 and 7 is if the calibration data should appear on both analog outputs or just analog output 1. If a 3 is selected for the ones digit, no calibration data will appear on analog output 2 and this output will hold lost value during the calibration cycle.

The tens digit for the set-up mode controls the function of both the digital inputs (3-6) and the relay outputs(1-4). Digital input 1 has a fixed function to enable programming and input 2 is fixed to start a calibration. Digital inputs 3-6 have the same function for set-up mode 0X through 5X. When the tens digit is a 6 the digital inputs 3 through 6 will be to start individual phases of the calibration cycle. In addition to changing the function of the digital inputs, the tens digit of the set-up mode will control the function of relays 1 through 4 as shown above.

6.1.1.2 RANGE 1 OUT.-1

Each analog output has 2 measuring ranges. The analog output is normally in range 1 but it is possible to close a digital input and change to a new measuring range. The value displayed here is for range 1 of analog output 1. The value displayed hear will equate to the 20 ma point of the analog output (4.00 ma will be zero percent opacity). The minimum range is 0 to 20% and the maximum range is 0 to 100% opacity and can be set in 1% steps. This is normally set to 100%.

6.1.1.3 RANGE 2 OUT.-1

This is range 2 of analog output 1. If digital input 4 was closed and the system was in set-up mode 0X through 5X, analog output 2 would change to Range 2. t is very rare that this would ever be done. This value is normally set to 100% (same as range 1).

6.1.1.4 INT. TIME OUT.-1

This is the integration time for analog output 1. This can be set from 5 seconds to 1800 seconds. This is essentially the T95 time or the amount of time to reach 95% of the final value when a step change is applied. This value is normally set to 5 seconds from DURAG to meet the ASTM/EPA 10 second response time specification.

6.1.1.5 RANGE 1 OUT.-2 These are basically the

6.1.1.6 RANGE 2 OUT.-2 same functions as above

6.1.1.7 INT. TIME OUT.-2 but for analog output 2.

6.1.1.8 CHECK CYCLE => HRS

If digital input 2 is left open, the system will go through a calibration cycle periodically by its own timer. The value set here is the time in hours between calibration cycles. This can be set from 1 to 99 hours. If you want the D-R 290 to initiate the calibration every day, this is set to 24 hours. If you want the data logging system to start the calibration, have the data logger close digital input 2 and disable the timer function. When you want the calibration to start, have the data logger open digital input 2 and the calibration will start. The amount of time to open digital input 2 should be at least 1 second (5 is typical) but digital input 2 must close before the internal timer forces another calibration. Some data logging systems can not hold a contact closed for 23 hours and 55 seconds. In this case the time between calibrations could be set this to 25 hours (some value larger than 24). 24 hours from the last calibration the data logger could close digital input 2 for 5 seconds and when this contact opened, the calibration would start. In this case you do not want this time set to 24 hours because you may end up in a race condition to see if the D-R 290 AW timer or the data logger timer reaches 24 hours first. This is why when the data logger initiates the daily calibration this value is normally set to 25 hours.

It is also possible to start a calibration cycle by pressing both the + key and the left arrow ( ) key and hold for at least 5 seconds.

6.1.1.9 WINDOW ALARM

During the daily calibration (or whenever a Window Check is activated), the system will measure the amount of contamination on the exposed optical surfaces (window and zero point reflector). This window check value is then used to compensate the measured opacity to get a more accurate reading of true stack opacity. The EPA allows for a maximum of 4% opacity compensation so this value is normally set to 3.5%. If you want more warning before the maximum allowable compensation is reached, this value can be set to 3.0%. When the value set here is reached, a Error 001 (window contamination exceed) will be generated that will cause a forced message in the display of the D-R 290 and the Warning Relay (R6) will energize.

6.1.1.10 LIMIT VALUE 1

Limit value 1 can be set on either analog output 1 or analog output 2 depending on the set-up mode. The value set here is in milli-amp (not %) and can be set in 0.1 ma steps. When this level is exceeded, the appropriate relay as determined by the set-up mode will close.

6.1.1.11 LIMIT VALUE 2

A second limit value can be set if in the appropriate set-up mode. This functions similar to limit value 1.

6.1.1.12 FILTER AUDIT

This mode is designed so the neutral density filters can be placed into the light path. In this mode the zero point reflector of the transceiver swings into the light path and the system is no longer measuring stack opacity. Before the filter audit test is performed, the optics should be clean and calibration cycle should have been ran so any changes in the window contamination reading from the cleaning will be updated. Undo the 4 clasps and swing the optic head open. The filter holder is located between the exit window and the zero point reflector. The filter holder is designed to accept the standard 2 inch square filters mounted in a 2.5 inch wide frame.

Once you step to this parameter, the zero reflector will swing into the light path and the display will read FILTER AUDIT. The display should read 0.0 +/- 0.2 % opacity and then the filters can be placed in the filter holder. If the display does not show this value, it is possible to adjust this to zero. Press the STO key and the red LED will light. Wait 10 seconds and press the STO key again and the LED will turn off. The value should now have automatically adjusted to 0.0 +/- 0.2 % opacity.

6.1.1.13 ZERO POINT CHECK

The system will now read and display the zero point check value.

6.1.1.14 WINDOW CHECK

The system will now read and display the contamination on the exit window and the zero point reflector. When this test is performed a compensation value is calculated from the contamination on the optics. Subsequent opacity measurements are corrected by this compensation value to give the correct stack opacity reading. When you view the window check, remain at this step for at least 10 seconds to allow for a stable reading. If you step through this value too quick, the window check value that is stored may be wrong and then generate the wrong correction value and could give a window check error (error 001).

6.1.1.15 SPAN CHECK

During this test(also called upscale calibration check), the zero point reflector is still in the light beam and internally, a metal grid filter is moved in the light beam. This attenuation of the light beam will cause an increase in opacity which will be displayed.

6.1.1.16 Stack Correction Factor

The stack correction factor is defined at the stack exit ID divided by the measuring path distance. This is shown in section 3.2 as L2/L1. A straight stack will normally give a stack correction value of 1.000. Sometimes a straight stack will have a stack correction factor slightly over 1 because the flange tubes protrude through the stack wall and into the stack. The range of allowable values for the stack correction factor is 0.5 to 2.9. The 4 to 20 ma will also equate to this 0.5 to 2.9. A stack correction factor of 1.000 will give a signal of 7.33 ma on the analog output.

6.1.2 Key functions

Key	MOD	Puts the system into the "*display parameters*" mode. The MOD key LED should be lit in this mode and then you can use the "+" key to scroll through and view the parameters. In this mode the parameters can only be viewed, they cannot be changed.
Key	STO	Puts the system into the "*data entry*" (save) mode. Digital input 1 must be bridged to allow a parameter to be changed. If digital input 1 is open you will see an "Input disabled" message when you try to activate this button. To change a parameter, first use the MOD and "+" key to view the parameter you wish to change. Then press the STO key (the LED will light) and you will see a blinking cursor. Use the arrow key to move the cursor to the digit you wish to change and then use the "+" key to change the digit to the desired value. Then press the STO key again and the LED will go out and the new value is saved. The LED on this button will blink during a fault.
Key	+	Pressing this key in the *"Display measured value"* (the normal measuring mode) switches the display between viewing the data on analog output 1 or analog output 2. The MOD key LED should not be lit. In the "*Display parameters*" mode, this key will cause the display to step to the next parameter. The MOD key LED will be lit. In the "*data entry*" mode, this will change the value of the blinking digit. LEDs on both the MOD and STO keys will be lit.
Key	←	This key moves the blinking cursor to the next digit in the display. It is active only in the "*data entry*" mode. The LEDs on both the MOD and STO keys will be lit.

(Fig. 6.2) D-R 290 AW Key Functions

6.1.3 Saving / Data entry

The D-R290 AW control panel requires digital input 1 to be bridged to enable changing and saving data. If digital input 1 is open. You will not be able to change the parameter. In the D-R 290 BT panel mount housing, digital input 1 is on Plug 2, contact 2D and 2Z. When the D-R 290 AW is in the D-R 290 AG wall mount housing, digital input 1 in on the terminal strip, terminals 20 and 40.

Open: Save function disabled, closed: Save function enabled.

1. Pressing the "MOD" key takes the system out of "*Measuring*" mode and puts it into "*display parameters*" mode. The LED on the MOD button should light.
2. Press the "+" key until the desired value appears in the display field.
3. Press the "STO" key to switch into "*data entry*" mode. The LED on the STO key should light up.
4. One of the digits should be blinking. Pressing the "+" key will increase this number (zero will appear after reaching the number 9). Pressing the " ← " key will move the blinking cursor to the next digit to the left. Again, press the "+" key until the desired number appears. When all digits have been adjusted, the cursor will automatically return to the right-most digit.
5. Pressing the STO key will save the newly entered value and return the system to the "*display parameters*" mode. The LED on the STO key should go out.
6. Pressing the MOD key while in the "*display parameters*" mode will return the system to the "*measurement*" mode. The MOD key LED will go out and the display will show the current measured value.

   If the MOD key is pressed during the "*data entry*" mode before saving, the system will revert to the "*measurement*" mode without saving changes.
7. After changes have been made and saved, digital input 1 can be opened to disable further changes.

	Operating mode	Key sequence	Explanation	Display
	Display measured value			Measured value
		+	Switch the display between the measured value output signal channels	Output 1 Output 2
1	Display parameters	MOD	MOD - LED lights	Measured value
2	Select	+	Select the value you wish to view	Saved value
		Enable data entry. Close the status relay contact input.		
3	Data entry	STO	STO - LED lights	
4	Change value	+	Increase the digit value	Previously saved value
		←	Change digit/move blinking cursor	
5		STO	Save the adjusted value	Changed value
	Display parameters		STO - LED goes out	
6		MOD	If the STO key has not been pressed, the changes will not be saved	
7	Display measured value		MOD - LED goes out	Current measured value
		Disable data changes by opening the status relay input		

(Fig. 6.3) D-R 290 AW operating sequence

6.1.3 Liquid Crystal Display (LCD)

The display has two 16-character lines and these two lines are divided into 4 sections as shown below. All error and warning messages appear in the first line (sections 1 and 2). In the event of an error, the display will alternate between the error message (see page 46 for error messages) and the currently selected display mode.

The display is divided into four sections.

Display during normal measuring

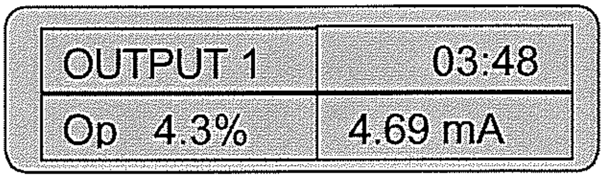
Section 1: Currently selected output

Section 2: If the system is set to automatically run the control cycle at regular intervals, this will display the time remaining until the next control cycle.

Section 3: Calculated value of the current measurement.

Section 4: Current analog-output signal in mA, from output 1 or 2.

Section 1 ***Section 2***



Section 3 ***Section 4***

Calibration Cycle Display

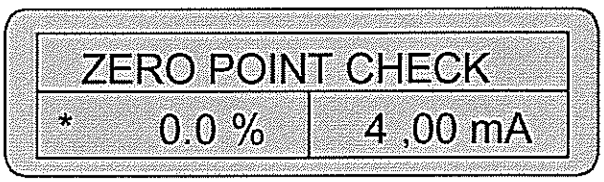
Section 1+2: Current phase of calibration cycle

ZERO POINT CHECK, WINDOW CHECK, SPAN CHECK, STACK COR.CHECK

Section 3: Calculated value in % opacity

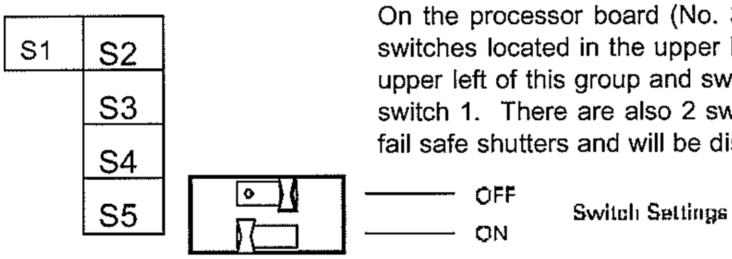
Section 4: Analog-output signal in mA for the current phase

Section 1 ***Section 2***



Section 3 ***Section 4***

6.1.4 Switch settings and Operation with or without the D-R 290 AZ



On the processor board (No. 30) inside the D-R 290 AW (and AZ) there are 5 switches located in the upper left corner of the circuit board. Switch 1 is in the upper left of this group and switch 2 through switch 5 are stacked to the right of switch 1. There are also 2 switches on the No. 40 board but these are for the fail safe shutters and will be discussed in the shutter section.

Most of the switches should be in the on position. In the on position the switch will be slid towards the rear of the circuit board (away from the display)

Switch	D-R 290 AW Function	D-R 290 AZ Function
S1	ON means Watchdog Timer on. The default is ON.	Same as AW
S2	ON to work without AZ, OFF when AZ is used	NA, Leave in ON position
S3	Setting of OFF will force analog outputs 1 and 2 to 20 ma which can be adjusted with P1 and P2	Same as AW
S4	Display amplification and LED-current when set to OFF.	Same as AW
S5	IF switch is OFF and digital input 1 closed before power is applied, turning on power will cause default data to be written from EPROM to RAM. Display will show "System Status". After 10 seconds turn off power and switch 5 ON. Only used when changing software versions in AW.	NA, Leave in ON position

(Table 6.4) D-R 290 AW and AZ processor board switch functions

Since the hardware of the D-R 290 AW and the D-R 290 AZ is identical, it is possible to change the software and make one unit function as the other. This may be useful during trouble shooting or it may be convenient to turn a D-R 290 AZ in a wall mount housing (possibly a spare) into a D-R 290 AW (operation without AZ) to perform a clear path of the opacity monitor. When using the electronic insert as an AW or AZ, it is important to remember to get the switches in the correct position, connect the RS 422 wires or jumpers (see electrical installation), and if you are changing software versions in an AW or changing an AZ to an AW, load the software constants from the EPROM as described above.

6.2 Operation of the D-R 290 AZ Stack Display Unit

The operation of the D-R 290 AZ is nearly the same as the D-R 290 AW. The most important difference is that no parameters can be modified from the D-R 290 AZ, it is display only. However the phases of the calibration (zero check, window check, span check, and stack correction factor) can still be initiated. The relay outputs and digital inputs are also different and this can be seen in section 5.3.1.

6.3 Reflector Operation

The following reflectors can be used with the D-R 290 opacity monitor:

Type	Flange to flange stack distance	Model
reflector 2	Between 5.75 and 45 feet (1.75–14.00 m)	Glass corner cube with optics
reflector 1	Between 1 and 7.5 feet (0.5–2.25 m)	Scotchlite

The reflector should be selected according to the opacity flange-to-flange distance. If the stack diameter is 3 feet, then have 2 foot long, 4" ANSI flanges on each side of the stack, then have 6" long adapter flanges to adapt from the ANSI to the opacity monitor, the flange to flange distance will be 8 feet even though the stack diameter is only 3 feet. This example would then require a type 2 reflector.

Since the reflector is passive the only action required is an occasional cleaning. When the window check indicates the transceiver optics require cleaning, the measuring reflector should be cleaned as well. Keeping a good purge air is also important in keeping the reflector and transceiver optics clean. The type 1 reflector is a Scotchlite material that can be damaged by high temperatures that could be encountered when the purge air fails.

6.4 Transceiver Operation

6.4.1 Maintenance

The D-R 290 MK opacity monitor transceiver requires little attention during normal operation. Periodically, when indicated by the window check results during the daily calibration, it may be necessary to clean the window and the zero point reflector with a soft cloth. Sometimes it may be helpful to use water, alcohol, or glass cleaner to clean the optics. Be careful if a cleaning solution of some type is used that it does not leave a film (this could adsorb light) and it does not have any abrasives that could scratch the optics. In most cases a clean, dry, soft cotton cloth will work fine.

The time between maintenance will vary based on the conditions at the installation. The stack conditions as well as the ambient conditions will determine the maintenance frequency. In general, a check of the equipment should be made every month. This includes a check of the fail-safe shutter system, if applicable.

A maintenance routine should include the following steps:

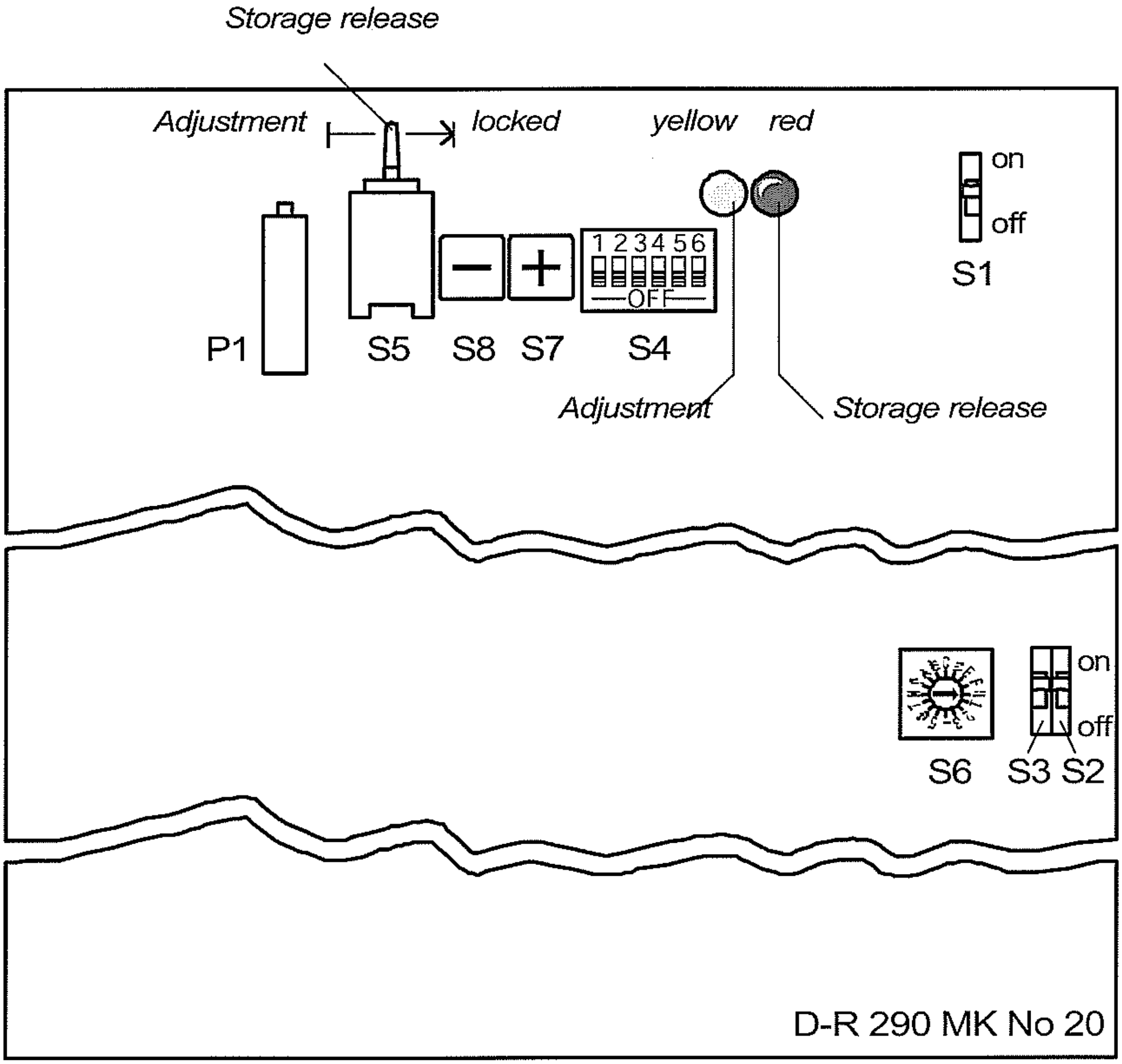
1. <u>Clean the external parts of the unit.</u>
2. <u>Check the condition of the fail-safe shutters.</u>
3. <u>Check all seals and mounting hardware.</u>
4. <u>Check the purge air system and the air hose.</u>
5. <u>Check the filters:</u> Although it may be possible to clean the air filter, it is usually better just to replace. The replacement elements are inexpensive and with cleaning there is always the risk of tearing the filter. The maintenance interval will depend on the dust loading in the ambient air. **NOTE: Keeping a good flow of purge air is the single most important step for the longevity of the opacity system.**
6. <u>Cleaning the external optics:</u> After opening the clasps on the housing, the transceiver and reflector can be swung open. Use a clean optics cloth to clean the transceiver window, zero point reflector, and the measuring reflector.
7. Any deposits or build-up in the mounting flanges should be removed. Dirt on the fail-safe shutter can be removed with a brush or cloth and a cleaning solution that dries without leaving a residue. Never use a solution that damages aluminum.

Warning!
Do not insert fingers into the fail-safe shutter system.
Serious injury may result!

6.4.2 Transceiver circuit board

There is only one circuit board, the D-R 290 MKLP20, in the transceiver. Values that affect the measurement of transmission and in turn opacity are stored on this circuit board. The D-R 290 AZ stack display or the D-R 290 AW evaluation unit can be replaced without changing the opacity measurement (as long as the stack correction factor in the D-R 290 AW remains the same).

The opacity system is normally adjusted at the factory for a specific installation. It should not be necessary to adjust the system. However, it may occur that the stack dimensions given to Durag, inc. came from stack drawings or were not correct for some other reason. Another reason the system may need to be adjusted is if the monitor is relocated. To adjust the opacity transceiver the switches on this main circuit board to be changed. The location of these switches is shown in the diagram below. **NOTE:** Make sure there is a valid reason before performing any adjustment. For example if a dear path procedure is run on the stack with opacity in the stack, the system has been "re-zeroed" and the opacity reading from the system will be wrong.



(Fig. 6.5) Transceiver switch functions

6.4.2.1 Transceiver Switch Functions

When using these switches, pay special attention to the switch position. Due to the microprocessor logic, sometimes the switch function is activated by turning the switch off. Some of the switches have a default position of on and some off. This manual will try to use up and down arrows (↑ or ↓) whenever possible to show the position of the switch.

Switch S1

This is for the watchdog timer function for the processor. The default position of this switch of this switch is off ↓ (in the down position) which will turn the watchdog timer on. This switch should be in the down position and not be moved.

Switch S2

This switch allows (in combination with S3 and S5) for special adjustment procedures such a clear path adjustment and LED current setting. This switch can also be used with S6 to access special test routines. How to use these switches is described in the appropriate section (clear path adjustment, window check adjustment, etc.). The normal position of this switch is ↓ (off).

Switch S3

This switch allows (in combination with S2 and S5) for special adjustment procedures such a clear path adjustment and LED current setting. This switch can also be used with S4 to adjust individual measurements such as the window contamination reading or the stack opacity zero. The normal position of this switch is ↓ (off).

DIL- Switch S4

S4 is actually 6 individual switches that are numbered 1 through 6. In an adjustment procedure you may see one of these switches referred to as S4/1. This means switch 1 of the S4 block of switches. This switch is enabled by S3. The default position for all 6 of these switches is the ↑ up or on position. To activate the feature associated with the individual switch, the switch will be slid down ↓ to the off position. Only 1 of these switches will be in the down ↓ position at any time. Use these switches with caution since the accuracy of the monitor may be changed.

S4/	Function
1	Slope in measurement mode
2	Slope in filter audit mode
3	Slope in span check
4	Offset in internal zero point (window check)
5	Offset in external zero point (measurement)
6	Basic calibration (reference light path gain setting and in turn LED current is set. **Warning: This will destroy all stored transceiver parameters.**

Switch S5

This is the blue toggle switch near the top of the circuit board. This is a 3 position switch back and center positions being fixed and the forward position is momentary. In the back position the system can not write any parameters to memory. This is the default position. The red LED will be off. In the center position data can be written to memory and saved. The red LED will be on. Moving the switch forward to the momentary position will start an automatic adjustment procedure that is determined by the position of switches S1 through S4. The yellow LED will blink.

Switch S6

This is a 16 position rotary switch that is only used for special test functions. The function of this switch is described in the service manual and will not be discussed further.

Switch S7 and S8

These are momentary push button switches used in conjunction with S4. S7 when depressed has the + (plus) function and is located next to S4. S8 has the – (minus) function and is located next to S5. In certain adjustment procedures, the D-R 290 AZ or AW display will show the plus and minus symbols. S7 or S8 will then be pressed to raise or lower the selected value.

6.4.3 Clear Path Procedure

In this procedure the measuring zero is set. The transceiver and reflector are mounted to the exact distance as on the stack or duct in a clean room with minimum dust in the air such as an air-conditioned office. This procedure then adjusts the monitor so that a zero percent opacity reading is obtained.

This procedure was done in the factory and normally will not be done in the field. Some examples of when this procedure would need to done in the field are: The flange to flange distance on the stack is not the same as was supplied to DURAG, the system is being relocated to a new measuring location with a different flange to flange distance, the measuring reflector was damaged by improper cleaning so the system needs to be re-zeroed, the D-R 290MKLP20 circuit board was replaced.

The values determined during the clear path procedure are stored in the transceiver. It may be convenient to leave the D-R 290 AW (and D-R 290 AZ if used) in their respective housings and use a spare D-R 290 AW (or D-R 290 AZ with AW software installed) mounted in a D-R 290 AG housing. This way all the existing wiring can stay in place.

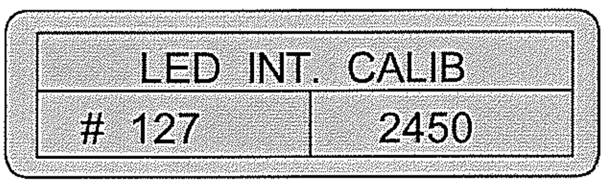
The display during adjustment

Segments 1 + 2: Current calibration function

Segment 3: Amplification factor

Segment 4: LED - Current

Line 1 ***Segment 1*** ***Segment 2***



Line 2 ***Segment 3*** ***Segment 4***

The clear path procedure should be run in the following order:

1. Set up the transceiver and reflector in a dust-free room to the exact optical path length as on the stack or duct. Make sure the test stands or flanges put the transceiver and the reflector in proper alignment. Make sure to include the appropriate allowances for the spring washers and fail-safe shutters if applicable. Clean the optical surfaces (transceiver window, zero reflector, and measuring reflector) with a soft, optics-safe cloth.
2. Open the four hasps on the transceiver and swing the housing open. With a 4 mm allen wrench, remove the six screws that secure the cover and remove it from the transceiver. Be careful not to drop the cover on the circuitry when removing the last screw. Swing the transceiver shut and latch the hasps. Supply power (connect plug "St1") to the transceiver and the DR 290 AW controller (and DR 290 AZ if applicable). Once turned on, the DR 290 will run a self-check cycle and check the value of the comparison light beam. The LCD display will read: **REF. LIGHT CHECK** on line 1. Once the automatic self-check has been completed and LED intensity has been set, the system can be calibrated (the yellow LED will go out).
3. Put switches **S2** and **S3** in the up, "**ON ↑** " position, Display line 1: **ZERO EXT. CALIB** .
4. Optically align the transceiver and reflector. (see section 5.4.1) It may be necessary to focus the transceiver if this system uses a reflector 1 and the path length was changed.
5. Return switches **S2** and **S3** to the lower, "OFF ↓" position, the push toggle switch **S5** towards the front of the monitor for 2 seconds. Switch **S5** can then be allowed to return to the center position. At this point the yellow LED should continue blinking and the red LED should be continuously lit. The lower line of the display (on the AW controller) should be working.
6. Display line 1: **LED INT. CALIB** the comparison light beam is calibrated. The LED current is fixed and the gain setting is determined to give a pre-determined output (8 volt at TP3).
7. Display line 1: **ZERO POINT CALIB** the internal zero point value is calibrated to determine the gain for the zero point reflector.
8. Display line 1: **SPAN CALIB** The reference light path is calibrated.
9. Display line 1: **ZERO EXT. CALIB** the external zero point value is calibrated.
10. After the clear path calibration procedure, the system automatically perform a calibration cycle. To allow these new clear path values to be saved, switch **S5** must be pushed back (the red LED will go out).
11. Loosen the 4 hasps on the transceiver head, swing open the transceiver, and replace the lid to the housing, making sure to secure all six screws. The transceiver head can then be closed and the hasps fastened again.

6.4.4 Manual internal zero point (Window Check)

Normally the window check reading should not need to be electrically adjusted. If the window check reading increases it indicates there is dust or contamination on the window or zero point reflector. Cleaning these surfaces should return the window check reading to near zero percent opacity (4.0 ma). At some time it may be necessary to adjust the window check reading back to zero. It is possible that over time the window or zero point reflector may have been scratched or damaged from improper cleaning or contamination on internal optics that is not possible to clean.

1. Clean the optical surfaces of the transceiver, the window and the zero point reflector, with a cloth designed for optics that does not leave any residue. Using the "MOD" and "+" keys on the control panel, select the "window check" measurement.
2. Remove the cover of the D-R 290 MK transceiver housing. On the circuit board, push switch **S4/4** on the 6-terminal switch **S4** to the OFF↓ position. Put switch **S3** (calibration function) to the ON↑ position. Toggle switch **S5** must be set to "free memory access" (the center position), so that the red LED lights. The first line of the display should alternate between "OFFSET - +" and "WINDOW CHECK".
3. Press push button **S8** [-] for a lower value and button **S7** [+] to increase the value to adjust the internal zero to 4.0 mA. Keep in mind that this new value will not take effect until after the 5-second integration time. Therefore, use the buttons briefly, and then wait at least 5 seconds before pressing a button again. The yellow LED should light when the buttons are being used.
4. At the end of the calibration, the switches should be returned to their normal positions. Switch **S5** should be set to OFF, which will turn off the red "data entry" LED. On the switch, **S4/4**, push **S4** to the ON↑ position. Switch **S3** should be put in the OFF↓ position. Place the housing lid back on the unit and tighten the screws.

6.4.5 External Zero Point Calibration

The external zero reading was also set at the factory to zero percent opacity and normally should not be adjusted. This procedure is basically one portion of the clear path procedure that was described above and can also be used to set the opacity reading to zero on a clear path. This procedure however will only affect the measured opacity reading and will not change the internal reference value or the window check reading. This procedure may need to be performed if the window or the measuring reflector is damaged.

1. Set-up the transceiver and the reflector in a dust free room (such as a clean office area) at the exact stack flange to flange distance and do the optical alignment. Clean the optics surfaces (window, zero reflector, and measuring reflector) carefully with a cloth designed for optical equipment. Check that the integration time is set to a short value (such as 5 seconds) or change if necessary on the D-R 290 AW control panel and return the system to normal measuring mode. The integration time is set to a small value to minimize the amount of time spent waiting for the adjustments to reach the final value.
2. Remove the cover for the electronics on the D-R 290 MK transceiver. On the circuit board, locate the 6-terminal switch **S4** and push the **S4/5** switch to the OFF↓ position and the calibration switch **S3** to the ON↑ position. Switch **S5** must be set to the "allow memory access" position (center position with the toggle lever straight up and down) so that the red LED lights. The first line of the display should alternate between "OFFSET - +" and "OUTPUT X".
3. Press button **S8** [-] for a lower value and button **S7** [+] to increase the value to adjust the external zero to 4.0 mA. Keep in mind that this new value will not take effect until after the 5-second integration time. Therefore, use the buttons briefly, and then wait at least 5 seconds before pressing a button again. The yellow LED should light when the buttons are being used.
4. At the end of the calibration, the switches should be returned to their normal positions. Switch **S5** should be set to OFF (back), which will turn off the red "enter value" LED. On the switch, **S4**, push **S4/5** to the ON↑ position. Switch **S3** should be put in the OFF↓ position. Place the housing lid back on the unit and tighten the screws. Reenter and save the old integration time on the D-R 290 AW control panel.

7. Error Messages

In the event of an error, the upper line of the LCD (segments 1 and 2) will alternately display an error message (as shown in the table) as well as the currently selected display. The LED on the STO key will also blink. After ten seconds, the associated relay contact will activate.

LCD-Display	ERROR	Probable Cause	R6	R5
ERROR 000	Communication error	1.Communication wires not connected correctly 2. RS 422 driver chip damaged (lightning) see schematics in service manual	X	X
ERROR 001	Window contamination exceeded	1. Window or zero reflector dirty – clean 2. Physical damage to window or zero reflector 3. Zero reflector loose or out of position		X
ERROR 002	External AW error 1	Input 1 has closed from external source- check connected device (DP Cell, switch)		X
ERROR 003	External AW error 2	Input 2 has closed from external source- check connected device (DP Cell, switch)		X
ERROR 004	EEPROM fault	Call DURAG for assistance		X
ERROR 005	RAM fault	Call DURAG for assistance	X	X
ERROR 006	PROM fault	Call DURAG for assistance	X	X
ERROR 007	AW system fault	Call DURAG for assistance	X	X
ERROR 010	Comparison normal error	Comparison signal out of specification-check Comparison normal reflector in transceiver		X
ERROR 020	External zero fault	System not able to determine valid gain setting for External zero during clear path-call DURAG		X
ERROR 030	Internal zero fault	System not able to determine valid gain setting for internal zero during clear path-call DURAG		X
ERROR 040	Stepper motor failure	Check zero reflector and filter wheel stepper motors And photo switch in transceiver for proper operation	X	X
ERROR 050	LED fault	1. Replace LED assembly 2. Check for dirty/damaged internal optics 3. Faulty photo-detector	X	X
ERROR 060	Heated exit window fault	Exit window heat trace or wires damaged		X
ERROR 070	MK system fault	Call DURAG for assistance	X	X
ERROR 100	AZ input 1 fault (Blower transceiver side)	1. Blower failure or loss of power 2. Faulty DP cell		X
ERROR 200	AZ input 2 fault (Filter transceiver side)	1. Air filter restricted-replace element 2. Faulty DP cell		X
ERROR 300	AZ input 3 fault (Blower reflector side)	1. Blower failure or loss of power 2. Faulty DP cell		X
ERROR 400	AZ input 4 fault (Filter reflector side)	1. Air filter restricted-replace element 2. Faulty DP cell		X
ERROR 500	AZ input 5 fault	1. Blower failure transceiver side when shutters used 2. Shutter failure transceiver side		X
ERROR 600	AZ input 6 fault	1. Blower failure reflector side when shutters used 2. Shutter failure reflector side		X
ERROR 700	AZ system fault	Call DURAG for assistance	X	X

(Table 7.1) Error messages

8. Purge air system

The purge air system protects the monitor from contamination on the external optical surfaces and keeps the unit from overheating. Typically a ½HP centrifugal purge air blower is used on each side of the stack when the stack pressure is neutral or negative. When the stack pressure is 10 inches water column positive or more, a 1 HP blower is usually recommended.

When selecting the mounting location, the following conditions must be met:

- The air used should be as dry and dust-free as possible. In extremely dirty environments, it may be advisable to relocate the air intake or filter to a cleaner area.
- The air temperature should not exceed 104 F (40°C).
- There must be enough room to allow for changing the air filters.
- If the purge air unit will be mounted outdoors, a protective weather hood is available.

WARNING

The purge air system must be turned on at all times when the D-R 290 is mounted at the measuring location. This applies even when the D-R 290 itself has been turned off. Make sure the purge air unit electrical systems are secured separately from those of the D-R 290 itself.

9. D-SK 290 Fail-safe Shutters

If the D-R 290 monitor is intended for use on an exhaust duct or smokestack, in which a high stack-pressure is present, a failure of the purge air system can lead to serious damage or destruction of the monitor. To protect the system in such an event, D-SK 290 fail-safe shutters can be installed. The shutter system consists primarily of a motor-driven quick close shutter D-SK 280 and the D-SK AE control electronics with the air current sensor F2.

Installation of fail-safe shutters offers effective protection against this type of damage. The D-R 290 installation flange has long enough studs to allow the D-SK 290 fail-safe shutter between the flange and the transceiver or reflector. These fail-safe shutters mechanically block the opening between the monitor and the exhaust gas in the event of a blower fail or loss of power. Due to possible overheating, however, the D-R 290 should never be left on the stack without purge air for extended time periods.

The control electronics, D-SK AE, is the same for all DURAG products. The shutter will vary depending upon the DURAG product it is used with and type of mounting flange. Since the D-R 290 uses the same installation flange as the D-R 280 and D-R 281, the shutter used will be the same as used with the D-R 280. This is why the shutter for the D-R 290 will have the number D-SK 280 MA.

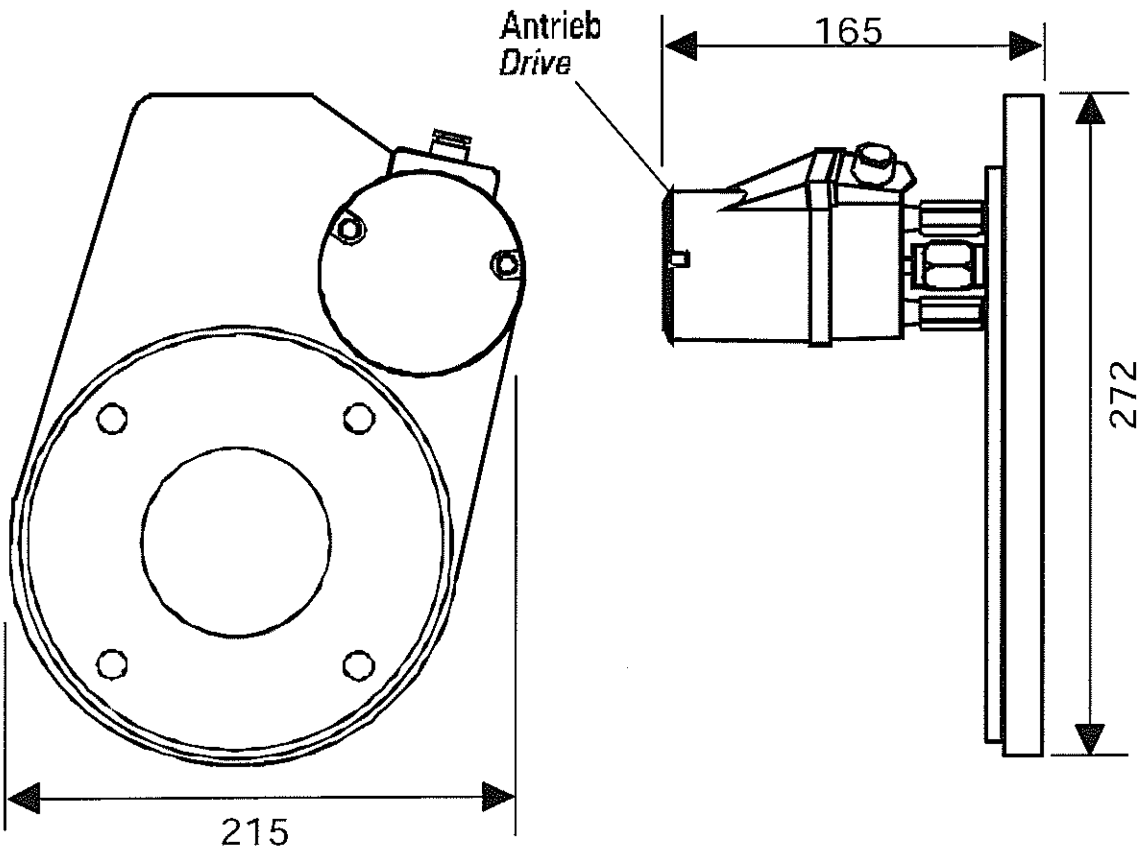
9.1. Function

After turning on the power supply and detecting purge air, the fail-safe shutter will automatically move to the "OPEN" position. If the power or the purge air blower fails, the shutter will close. For such an event, the D-SK AE electronics has a Ni-Cad battery pack to supply power to the shutter motor. After the problem has been corrected, the shutter will automatically open again. There are cams off the motor shaft that drive switches to give "shutter open" and "shutter closed" status signal. Terminals 7 and 8 in the D-SK AE will close when the shutter is open. Terminals 7 and 9 will be closed when the shutter is closed.

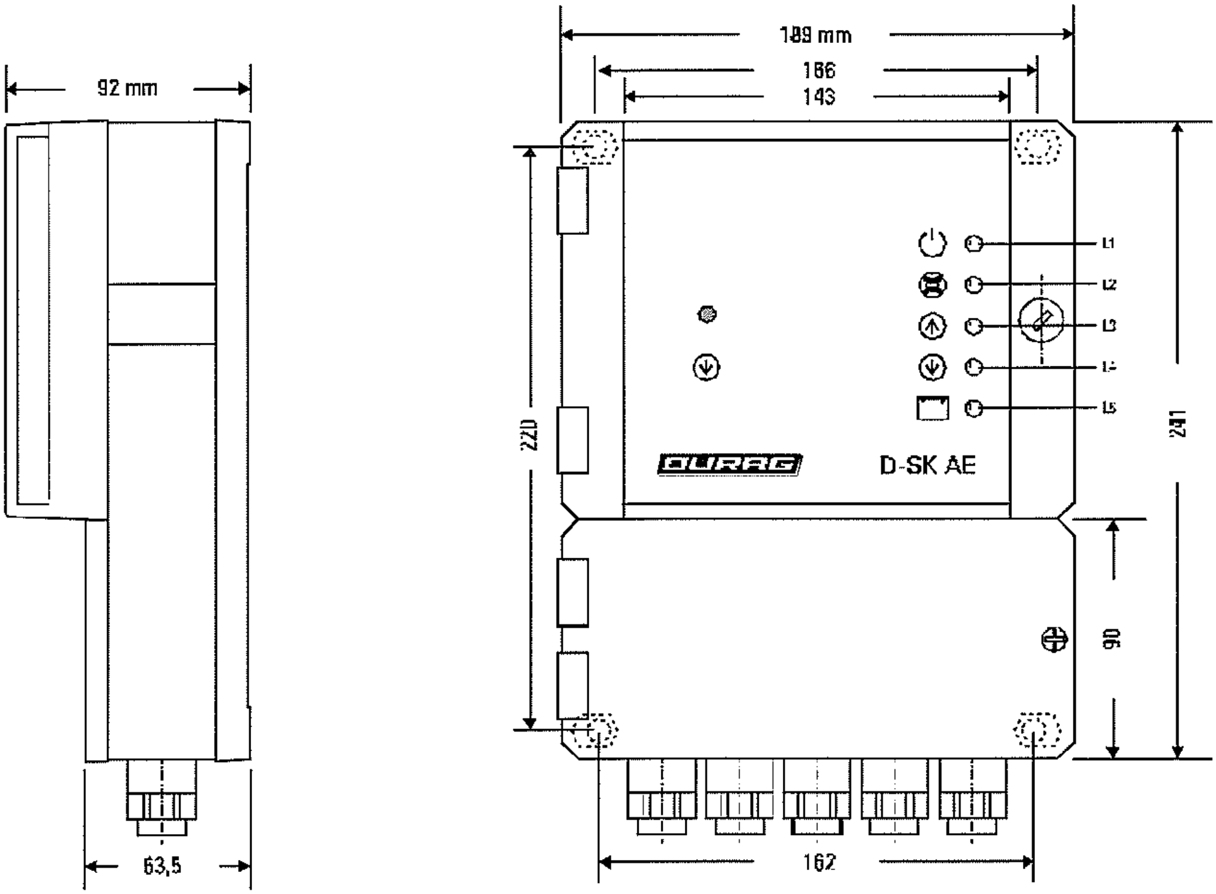
The battery charge is indicated by the *"battery charging LED"* on the front panel. The LED remains lit during rapid charging and blinks during a normal "float" charging. The fail-safe shutter can be manually closed by pressing the manual push-button (or flipping the toggle switch) on the front panel of the control electronics.

The D-SK 290 fail-safe shutter can be tested using the input relays (terminals 16 and 17) for "close shutter". When the connection between terminals 16 and 17 is opened, the shutter will automatically close. The shutter closed message is transmitted over terminals 7 and 8 (closed contacts).

Schnellschlußklappe D-SK 280 MA
Fail Safe Shutter D-SK 280 MA



(Fig.9.1) Dimensions (in mm) of shutter (D-SK 280 MA)

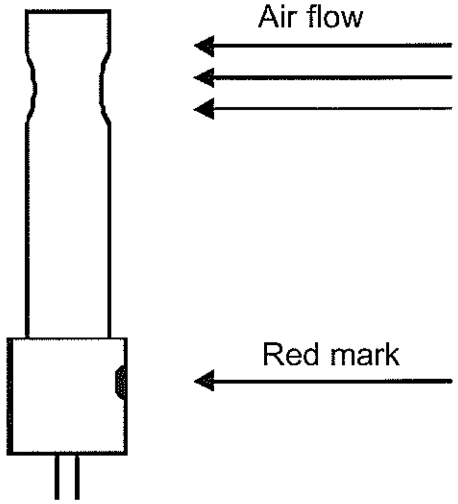


(Fig. 9.2) Dimensions (in mm) of control electronics D-SK AE

9.2. Installation

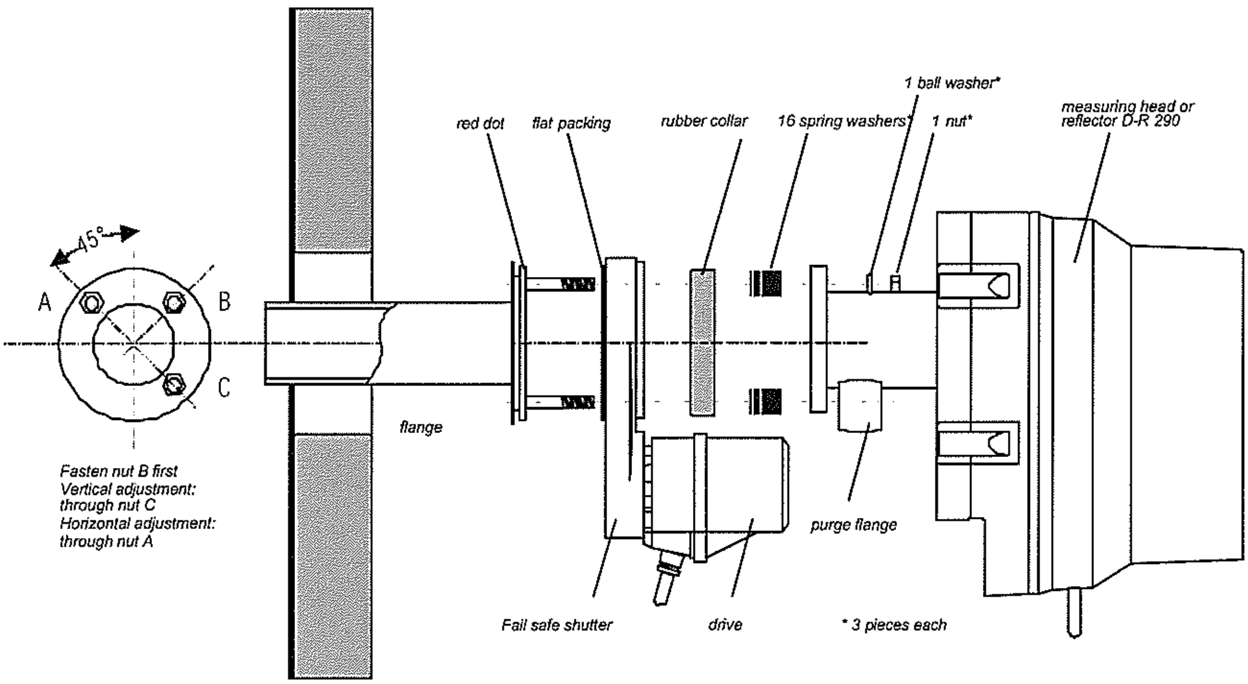
A D-SK 290 fail-safe shutter system is mounted on the transceiver and/or the reflector flanges, each with its own D-SK AE control electronics. The shutter can be mounted in any orientation so long as there is no interference with the weather hood or any obstructions near the installation flange. The D-SK AE control electronics are connected to the fail-safe shutter with a six conductor cable. This connection should be made after the monitor has been mounted to make sure the shutter can not open or close while it is being installed.

The air current sensor (F2) should also be connected to the purge air flange and then to the D-SK AE controller. The F2 sensor is threaded into the purge air duct with the red dot pointing towards the air flow and secured with a lock nut. This sensor will detect a failure of the purge air system. The cable (six feet are provided at no charge, additional cable is available) that runs to the fail-safe shutter can be as long as 150 feet (the air flow sensor cable has 3 wires including the shielding).



The air current sensor should be mounted on the system after removing the cover (PG7). The sensor should be positioned at the monitor opening such that the air current flows directly through the hole in the sensor. The red mark is meant to aid in mounting and should face away from the monitor in the direction of the air current.

(Fig. 9.3) ***Air Flow Sensor***

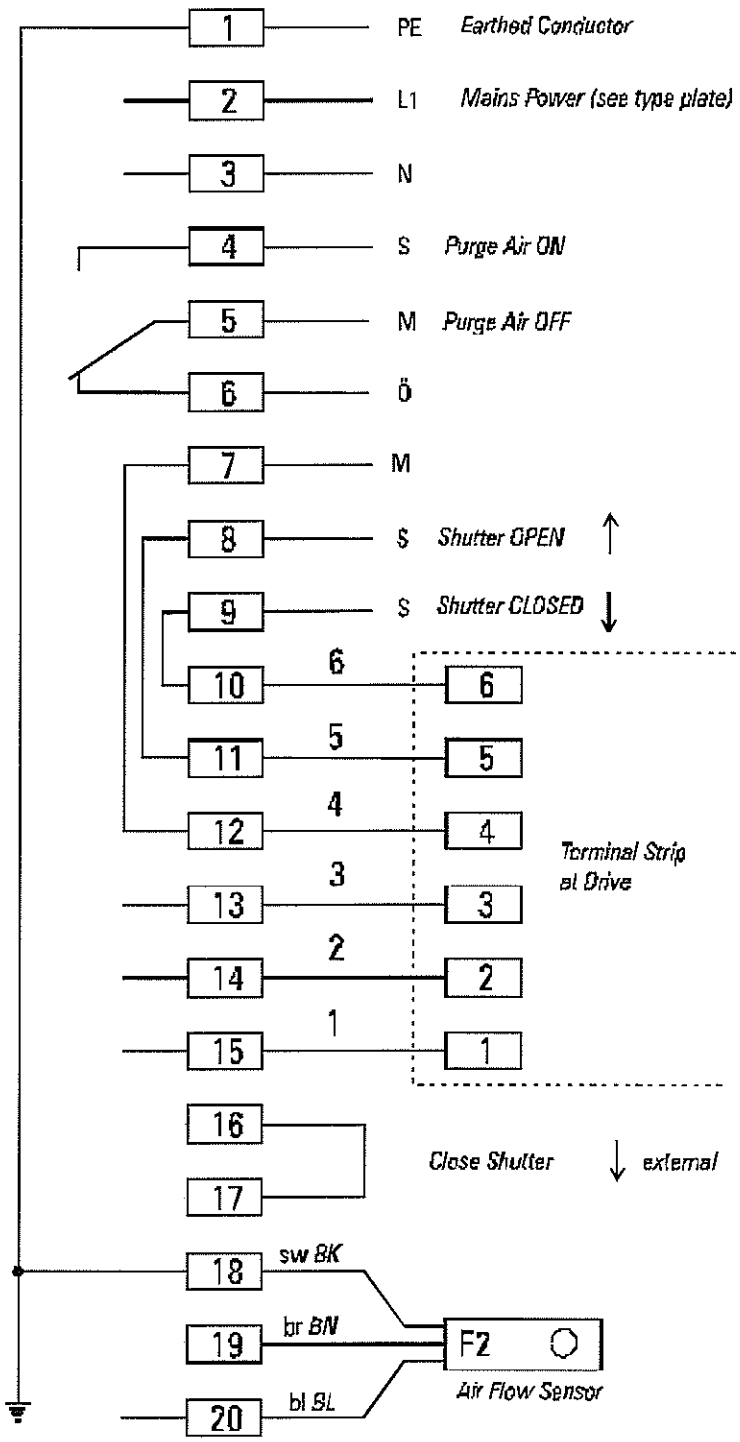


(Fig. 9.4) ***D-SK 290 Mounting***

> ## Warning!
> **Do not insert fingers into the fail-safe shutter system. Serious injury may result! Disconnect the unit by opening the connection at terminals 16 and 17 before conducting maintenance work on the D-SK AE.**

9.3. Electrical Connection D-SK AE

The electrical connection to the fail-safe shutter uses a 20-pin terminal strip in the connection box of the D-SK AE as shown in the diagram below:



(Fig. 9.5) Electrical Connection for the D-SK AE

9.3.1 Automatic check of shutter operation

The purge air system is very reliable so the shutter should not have to close very often. This however can create another problem. If the shutter has been open for several years, the shutter could be dirty or corroded and may not close when required. To prevent this from occurring the DR 290 has been designed to allow for the check of the operation of shutter every day. To activate this feature, the display unit (either the D-R 290 AZ or D-R 290 AW, whichever is connected to the transceiver) will need to have S1 and/or S2 as appropriate on the No. 40 board in the "ON" position. During the upscale calibration point check portion of the calibration cycle, relay output 3 (and 4 if there are 2 shutters installed) will close for approximately one minute. For the display unit to receive confirmation that the shutter(s) actually closed, the shutter electronics (D-SK AE) will provide a contact closure from terminals 7 and 9. This contact will be connected to digital input 5 for the first shutter and digital input 6 for the second shutter on the display unit.

<u>Switch S1</u> In the "ON" position in the No. 40 board in the DR 290 AZ (or AW), this switch activates relay output 3, and for the confirmation signal will be read by digital input 5 and will give the associated fault signal (ERROR 500).

<u>Switch S2</u> In the "ON" position in the No. 40 board in the DR 290 AZ (or AW), this switch activates relay output 4, and for the confirmation signal will be read by digital input 6 and will give the associated fault signal (ERROR 600).

During the reference point check, the D-SK 290 fail-safe shutter is closed by the relay output (contact opens). If the confirmation signal (shutter CLOSED), is not sent within approximately 2.5 seconds, the first line of the LC display will alternate between the current SPAN CHECK display and the error message (ERROR 500 or 600), and the LED on the "STO" key will begin blinking. After a 10 second delay, the fault relay output will signal the error.

D-SK AE 1			D-R 290 AZ display unit Connection block housing	
Function	**Terminal**		**Terminal**	**Function**
Shutter status	7	------->	36	Input 5 ← Error 500 (1 D-SK)
(open or closed)	9	------->	16	
Close or open	16	<-------	29	Relay 3 output switch
The shutter	17	<-------	9	For the fail-safe shutter #1 D-SK 290
D-SK AE 2				
Function	**Terminal**		**Terminal**	**Function**
Shutter status	7	------->	35	Input 6 ← Error 600 (2 D-SK)
(open or closed)	9	------->	15	
Close or open	16	<-------	28	Relay 4 output switch
The shutter	17	<-------	8	For the fail-safe shutter #2 D-SK 290

(Fig. 9.6) Electrical connection between the D-R 290 AZ and the fail-safe shutter

9.4 Shutter Operation

When starting the system, the battery charge level should be checked. The battery charge will be indicated on the red *"battery charging LED"* (L5) on the front panel. The LED will remain lit by rapid charging and will blink during normal charging (indicating that the batteries are charged). When the batteries are strongly depleted, a slow normal charging will occur first (with the LED blinking). When the batteries have reached a minimal charge level, the rapid charging procedure will begin.

If necessary the batteries can be charged before the first system start-up. To do so, connect the D-SK AE controller to the power supply before connecting it to the fail-safe shutters. The shutter motor is driven from the NI-Cad battery pack. The shutter motor draws more power than the Ni-Cad charging circuit supplies. If the shutter controller has sat for a long time without power the batteries may be too low to power the shutter motor. If this occurs, remove the 6 wires going to the shutter motor from the D-SK AE terminal strip. Let the batteries charge for at leas 2 hours and then re-connect the 6 wires for the shutter motor.

Normally the shutters will function fine as delivered. However in cases where the stack pressure is negative (more air drawn through the purge air system) or when the stack pressure is high (less air through the purge air system), it may be required to adjust the point at where the shutter opens and closes. To set the potentiometers, open the latch on the right side of the housing with a screwdriver. The housing can then be opened and the 2 potentiometers should be visible.

The "air flow" potentiometers (P1) and the "hysteresis" potentiometer (P2) are set to a minimum (turn potentiometers clockwise).

Once power is supplied, the unit is ready for operation. The yellow "stand-by" LED (L1) and red "close shutter" LED (L4) light up.

If the purge air unit is running, the "air flow" potentiometer (P1) should slowly be turned counter-clockwise until the green "air flow" LED (L2) lights up. The adjustment is completed by turning the potentiometer half a turn counter-clockwise beyond this switching point. The green "open shutter" LED (L3) lights up and the shutter is automatically moved to the "OPEN" position.

The switch hysteresis is set using the "hysteresis" potentiometer (P2) such that erratic switching is avoided, but without making the switch hysteresis too great.

After settings have been made the housing is closed and latched. The proper function of the fail-safe shutters may be checked by briefly shutting off the purge air supply or detaching the purge air hose. A delay period for the closing of the shutter is necessary, since the air flow sensor will only detect an absence of purge air after a short time period.

10. Technical Specifications

10.1 Technical Specifications: D-R 290

Measuring range for a three foot (one Meter) long measuring path:	From 0-0.08 to 0-1.75 grains/ft³ (0-200 mg/m³ to 0-4000mg/m³)
Light source:	Super Wide Band Diode (SWBD)
Measuring range	
Extinction:	0,1 - 1,6 Ext.
Opacity:	0-20 to 0-100% Measuring ranges can be switched
Measurement path length:	3-46 ft (1 - 14m)
Output signal:	2 x 0 - 20mA, Low scale value 4mA
Maximal load:	500 Ohm
Relay outputs:	6 x Status, potential free (limit value, error, control cycle, etc.)
Maximal switch capacity:	250V, 100VA
Inputs:	6x Status (Data entry enable, purge air error, 2x switch measurement range, control cycle)
Output signal integration time:	5 - 1800s, each output independently set in 1 s - increments
Ambient temperature:	-40° to 122°F (-40°C to +50°C)
Stack gas temperature:	above the dew point
Enclosure rating:	NEMA 4x (IP65)
Weight	
Transceiver:	approx. 22 lbs (10 kg)
Reflector:	approx. 15 lbs (7 kg)
Electrical Specifications:	
Power supply:	90 - 264V, 48 - 62Hz
Power:	approx. 30W

10.2 Technical Specifications for the Purge Air Blower

Supply voltage:	115/230V, 50/60Hz,	Other voltages and frequencies available upon request
Power consumption:	5.0/2.5 amps for ½HP	
	8.6/4.3 amps for 1 HP	
Air flow at 0 backpressure:	56 cfm (1/2 HP), 98 cfm (1 HP)	
Weight:	27 lb (1/2 HP), 51 lb (1 HP)	

10.3 Technical Specifications for the D-SK AE Electronics

Power supply	:	115 / 230 Volt ± 10% 48 / 62 Hz
Fuse	:	0.1 A, slow blow
Power	:	approx. 10 VA
Motor driver	:	24 Volt DC
Enclosure rating	:	IP 65 DIN 40050 (NEMA 4X)
Weight	:	approx. 7.75 lbs (3.5 kg)

Contacts:
1 contact shutter "closed",
1 contact shutter "open",
1 contact switch " purge air " present / failure

All contacts are potential-free, max. 250 Volt 100 VA switch capacity with resistive load.

Display messages:
5 Display-LEDs for the messages:
" Stand by ",
" Purge air present ",
" Shutter open ",
" Shutter closed "
" Battery charge status " –this LED is lit constantly when the batteries are charging rapidly and blinks during a normal slow charge.

Sensitivity:

Adjustable, minimum approximately 16.5 ft/s (5 m/s) air flow velocity

10.4 Technical Specifications for the D-SK 290 MA Mechanics

Driver	:	24 Volt DC driver with built-in motor overload switch.
Torque	:	8 Nm
Run time	:	approx. 2 seconds from open to closed
Shutter	:	Stainless steel 1.4571
Housing	:	Aluminum
Enclosure rating	:	NEMA 4x (IP 65) DIN 40050
Weight	:	Approx. 10 lbs (4.5 kg)

08 / 2001R1

DURAG

D-R 290
Service Manual

DURAG, Inc. 1355 Mendota Heights Road, Suite 200
Mendota Heights, MN 55120 · Tel. 651-451-1710 · Fax 651-457-7684

Contents

Figures

Document	:	man_dsr290_de3007.doc
Author	:	Günter Müller
Version	:	07 / 2001
Printed	:	05.09.03

1 D-R 290 AW Controller

1.1 Key Function

Key [STO] Puts the system into the "*data entry*" (save values) mode.
The LEDs on the "STO" and "MOD" keys will light in this mode. The Led on the "STO" key will blink to indicate a fault.

Key [MOD] Puts the system into "*display parameters"* mode
The LED on the "MOD" key will light in this mode.

Key [+] When the system is in the "*display measurements"* mode, this key will toggle between outputs 1 and 2. The LED on the "MOD" key will not be lit.
When the system is in the "*display parameters"* mode, this key will move to the next display screen. The LED on the "MOD" key will light.
In the *"data entry"* mode, this key will increase the value of the blinking digit by one. The "STO" and "MOD" keys will light.

Key [←] This key changes the position on the blinking cursor in the display. This key is only active in the "*data entry*". The "STO" and "MOD" keys will light.

If the cursor and the plus keys are pressed simultaneously for about five seconds, a calibration cycle will start.

1.2 Saving / DataEntry

The D-R 290 AW controller has a status relay input to enable data entry/ saving value: Plug 2, contacts 2 D - 2 Z = Terminals 20 - 40.
<u>Open: Data entry disabled, closed: data entry enabled</u>

1. Pressing the "MOD" key switches from the "*Measurement*" mode into the "*Display Parameters*" mode. Once in measurement, the LED on the "MOD" key will light.
2. Press the "+" key until the desired value appears in the display.
3. Pressing the "STO" key will put the system into "*Data entry*" mode. The LED on the "STO" will light.
4. The value of the digit blinking in the display will increase as long as the "+" key is pressed. Once "9" has been reached, "0" will reappear. The " ← " key will move the blinking cursor one digit to the left. Once the left-most digit is selected, pressing the key again will move the cursor back to the farthest right digit.
5. To save the newly entered values and return to the "display parameters" mode, press the "STO" key. The LED on the "STO" key will go out..

6. In the "*display parameters*" mode, pressing the "MOD" key will toggle the system back to the "measurement (display measurements)" mode. The light on the "MOD" key will go out and the current measured value will be displayed. However, if the "MOD" key is pressed while in "*data entry*" mode, the system will return to "*measurement*" mode without saving any changes.
7. Once all changes have been made in "*data entry*" mode and saved, close the terminals below to disable new data entries

   Plug 2, Contacts 2 D - 2 Z = Terminals 20 - 40.

1.3 Error Messages

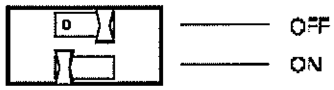
If a fault is detected, the top line of the LCD display will alternate between the current measured value and the error message. The LED on the STO key will also blink. After an approximately 10 seconds, an error message will be signaled on relay output 5. For fatal errors, a fault will also be signaled on relay output 6.

Errors 100 through 700 are specific to the D-R 290 AZ display.

ERROR	LCD-Display	R6	R5
Communication error	ERROR 000	X	X
Window contamination too high	ERROR 001		X
External AW error 1	ERROR 002		X
External AW error 2	ERROR 003		X
EEPROM fault	ERROR 004		X
RAM fault	ERROR 005	X	X
PROM fault	ERROR 006	X	X
AW system fault	ERROR 007	X	X
Comparison normal error	ERROR 010		X
External zero fault	ERROR 020		X
Internal zero fault	ERROR 030		X
Stepper motor failure	ERROR 040	X	X
LED fault	ERROR 050	X	X
Heated exit window fault	ERROR 060		X
MK system fault	ERROR 070	X	X
AZ input 1 fault	ERROR 100		X
AZ input 2 fault	ERROR 200		X
AZ input 3 fault	ERROR 300		X
AZ input 4 fault	ERROR 400		X
AZ input 5 fault	ERROR 500		X
AZ input 6 fault	ERROR 600		X
AZ system fault	ERROR 700	X	X

2 Switch Functions in the AW and AZ

By default, all switches are shipped in the ON position (towards back of unit).



Switch Settings

2.1 Switches on the D-R 290 AW No. 30 Circuit Board

Switch	ON	OFF	Function D-R 290 AW / D-R 290 AZ	D-R 290 AZ
S1	X		Watchdog Timer **ON**	
S2		X	Operate with D-R 290 AZ	N/A
S3		X	**TEST STEP # 16** Current to 20 mA at P1 + P2	
S4		X	Show amplification and LED-Current	
S5		X	System Status -> load	N/A

Switch S1:

OFF Position: The watchdog timer is turned off.
ON Position: The watchdog timer is turned on.

Switch S2:

If the D-R 290 monitor is installed with the D-R 290 AZ display, switch S2 in the D-R 290AW must be in the OFF position (pushed forward).

Switch S3:

For checking or calibrating the signal outputs, switch S3 should be in the OFF position. The LCD display will read **TEST STEP #16** (20 mA). Outputs 1 and 2 can be set to 20 mA using potentiometers P1 and P2 if needed.

Switch S4:

The LED amplification and current will be shown in the LCD display if switch S4 is in the OFF position. For maintenance purposes, the current measured value can also be displayed.

Switch S5:

If switch S5 is in the OFF position and status relay input 1 is closed (enable data entry mode) when the system is powered up, the factory default settings for the AW unit will be loaded and overwrite all parameters. The display will read **System Status ->.**

2.2 Switches on the D-R290AW and AZ No. 40 Circuit Board

Switch	ON	OFF	Function
S1	**X**		Relay 3 will be used for controlling the transceiver side D-SK 290 fail-safe shutter.
S2	**X**		Relay 4 will be used for controlling the reflector side D-SK 290 fail-safe shutter.

Switches S1: / S2:

It is possible to automatically test the function of the D-SK 290 fail-safe shutters during the span phase of the calibration cycle. To enable this feature, both S1 and S2 should be in the ON (pushed towards back of unit) position.

If the system installation includes the **D-R 290 AZ** display, this automatic fail-safe shutter test cannot be initiated by the D-R 290 AW controller but will be controlled by the D-R 290 AZ if S1 and S2 are switched on in the D-R 290AZ No. 40 board.

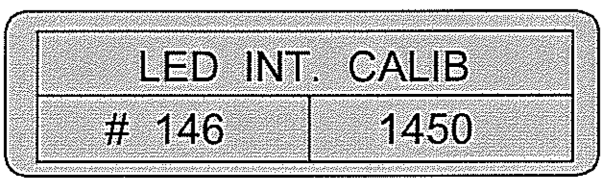
2.3 LCD Display During a Clear Path Calibration

Segment 1 + 2: Current calibration function:
LED INT. CALIB the comparison beam is set.
ZERO POINT CALIB the internal zero is set.
SPAN CALIB the reference value is set.
ZERO EXT. CALIB the external zero value is set.

Segment 3: Displays the amplification (10- 255), depending on the calibration function and the path length.

Segment 4: LED –current (0 to 4095). A current of 4000 corresponds to an LED – pulse rate of approx. 100 mA.

<u>**Line 1**</u> ***Segment 1*** ***Segment 2***



<u>**Line 2**</u> ***Segment 3*** ***Segment 4***

(Fig. 1) Display

Control unit D-R 290 AW		Only for Use with D-R 290 AW in wall mount housing No D-R 290 AZ is used						
Terminal	**Name**	**Function**						
PE	Ground	Power supply 90 - 264 Volt						
N	Neutral							
L	Line							
40	Digital Input 1	Programming Enable						
20								
39	Digital Input 2	Start Cal Cycle						
19								
38	Digital Input 3	Set up Mode 0x- External Error 002						
18		Set up Mode 6x Zero Check						
37	Digital Input 4	Set up Mode 0x- Range 2 for Analog Out 1						
17		Set up Mode 6x Window Check						
36	Digital Input 5	Set up Mode 0x- Range 2 for Analog Out 2						
16		Set up Mode 6x Upscale Calibration Check						
35	Digital Input 6	Set up Mode 0x- External Error 003						
15		Set up Mode 6x Display Stack Factor						
34	Relay 6	NO Measuring relay, energized when measuring.						
14		Commo Fault, in cal, or power off						
33		NC Relay is de-energized						
13	Relay 5	NO						
32		Commo Warning energizes relay						
12		NC						
Relays 1-4 Function Determined by set-up		0x	1x	2x	3x	4x	5x	6x
31	Relay 1	None	Limit 1 Analog1	Limit 1 Analog2	Limit 1 Analog1	Zero Check	Zero Check	Zero Check
11								
30	Relay 2	None	Limit 2 Analog1	Limit 2 Analog2	Limit 2 Analog2	Window check	Window check	Window check
10								
29	Relay 3	D-SK 1	D-SK 1	D-SK 1	D-SK 1	Upscale check	Upscale check	Upscale check
9								
28	Relay 4	D-SK 2	D-SK 2	D-SK 2	D-SK 2	Stack Factor	D-SK 1	Stack Factor
8								
27	RS 422 Link	**Note:** When using D-R 290 AW without D-R 290 AZ Terminals 6 and7 must be connected with a jumper and Terminals 26 and27 must be connected with a jumper to Complete the RS 422 communication to the transceiver						
7								
26								
6								
4	Analog out 2	plus	4 – 20 ma, 2nd Normally not connected	Data on analog Outputs (opacity, optical density, calibration results) is also Function of the Set-up Mode See table 2C				
5		minus						
24	Analog out 2	plus	4 – 20 ma, 1st termination					
25		minus						
2	Analog out 1	plus	4 – 20 ma, 2nd Normally not connected					
3		minus						
22	Analog out 1	plus	4 – 20 ma, 1st termination					
23		minus						
1		PE (Ground)						

Fig. 2a Optional wiring diagram. For D-R 290 AW installed in D-R 290 AG wall mount housing. D-R 290 AW is connected directly to transceiver. No D-R 290 AZ is used.

Control unit D-R 290 AW		For use when D-R 290 AW is connected to D-R 290 AZ							
Plug	**Terminal**	**Name**	**Function**						
Plug 2	32 D Z	Ground	Power supply 90 - 264 Volt						
Plug 2	28 D Z	Neutral							
Plug 2	30 D Z	Line							
Plug 2	2 D	Digital Input 1	Programming Enable						
Plug 2	2 Z								
Plug 2	4 D	Digital Input 2	Start Cal Cycle						
Plug 2	4 Z								
Plug 2	6 D	Digital Input 3	Set up Mode 0x-5x	External Error 002					
Plug 2	6 Z		Set up Mode 6x	Zero Check					
Plug 2	8 D	Digital Input 4	Set up Mode 0x-5x	Range 2 for Analog Out 1					
Plug 2	8 Z		Set up Mode 6x	Window Check					
Plug 2	10 D	Digital Input 5	Set up Mode 0x-5x	Range 2 for Analog Out 2					
Plug 2	10 Z		Set up Mode 6x	Upscale Calibration Check					
Plug 2	12 D	Digital Input 6	Set up Mode 0x-5x	External Error 003					
Plug 2	12 Z		Set up Mode 6x	Display Stack Factor					
Plug 2	14 D	Relay 6	NO	Measuring relay, energized when measuring					
Plug 2	14 Z		Common	(If in Fault, in cal, or power off					
Plug 2	16 D		NC	Relay is de-energized)					
Plug 2	16 Z	Relay 5	NO						
Plug 2	18 D		Common	Warning energizes relay					
Plug 2	18 Z		NC						
Relays 1-4 Function by set-up mode			0x	1x	2x	3x	4x	5x	6x
Plug 2	20 D	Relay 1	None	Limit 1 Analog1	Limit 1 Analog2	Limit 1 Analog1	Zero Check	Zero Check	Zero Check
Plug 2	20 Z								
Plug 2	22 D	Relay 2	None	Limit 2 Analog1	Limit 2 Analog2	Limit 2 Analog2	Window check	Window check	Window check
Plug 2	22 Z								
Plug 2	24 D	Relay 3	D-SK 1	D-SK 1	D-SK 1	D-SK 1	Upscale check	Upscale check	Upscale check
Plug 2	24 Z								
Plug 2	26 D	Relay 4	D-SK 2	D-SK 2	D-SK 2	D-SK 2	Stack	D-SK 1	Stack Factor
Plug 2	26 Z						Factor		
Plug 1	6D	RS 422 Communication	To D-R 290 AZG terminal 6						
Plug 1	6Z		To D-R 290 AZG terminal 26						
Plug 1	8D		To D-R 290 AZG terminal 7						
Plug 1	8Z		To D-R 290 AZG terminal 27						
Plug 1	16 D Z	Analog out 2	plus	4 – 20 ma, 2nd termination	Data on analog Outputs (opacity, optical density, calibration results) is also Function of the Set-up Mode See table 2C				
Plug 1	18 D Z		minus	Normally not connected					
Plug 1	20 D Z	Analog out 2	plus	4 – 20 ma, 1st termination					
Plug 1	22 D Z		minus						
Plug 1	24 D Z	Analog out 1	plus	4 – 20 ma, 2nd termination					
Plug 1	26 D Z		minus	Normally not connected					
Plug 1	28 D Z	Analog out 1	plus	4 – 20 ma, 1st termination					
Plug 1	30 D Z		minus						
Plug 1	32 D Z		? PE shielding for RS 422						

Fig. 2b Standard wiring diagram for D-R 290 AW in panel mount housing when AW is used with D-R 290 AZ .

Opacity: = **OP%**, Extinction: = Optical Density = **OD**

Set-up Mode I/O Function

Display 1s digit	***Output - 1 Measuring in***	***Output - 2 Measuring in***	***Control cycle on***
X 0 S	OD	OD	Output-1
X 1 S	OP%	OD	Output-1
X 2 S	OD	OP%	Output-1
X 3 S	OP%	OP%	Output-1
X 4 S	OD	OD	Output-1 + Output-2
X 5 S	OP%	OD	Output-1 + Output-2
X 6 S	OD	OP%	Output-1 + Output-2
X 7 S	OP%	OP%	Output-1 + Output-2

Display 10s digit	***Relay 1 Function***	***Relay 2 Function***	***Relay 3 Function***	***Relay 4 Function***
0 X S	X	X	D-SK 1	D-SK 2
1 X S	Limit 1, output 1	Limit 2, output 1	D-SK 1	D-SK 2
2 X S	Limit 1, output 2	Limit 2, output 2	D-SK 1	D-SK 2
3 X S	Limit 1, output 1	Limit 2, output 2	D-SK 1	D-SK 2
4 X S	Zero Check	Window check	Upscale check	Stack Factor
5 X S	Zero Check	Window check	Upscale check	D-SK
6 X S	Zero Check	Window check	Upscale check	Stack Factor

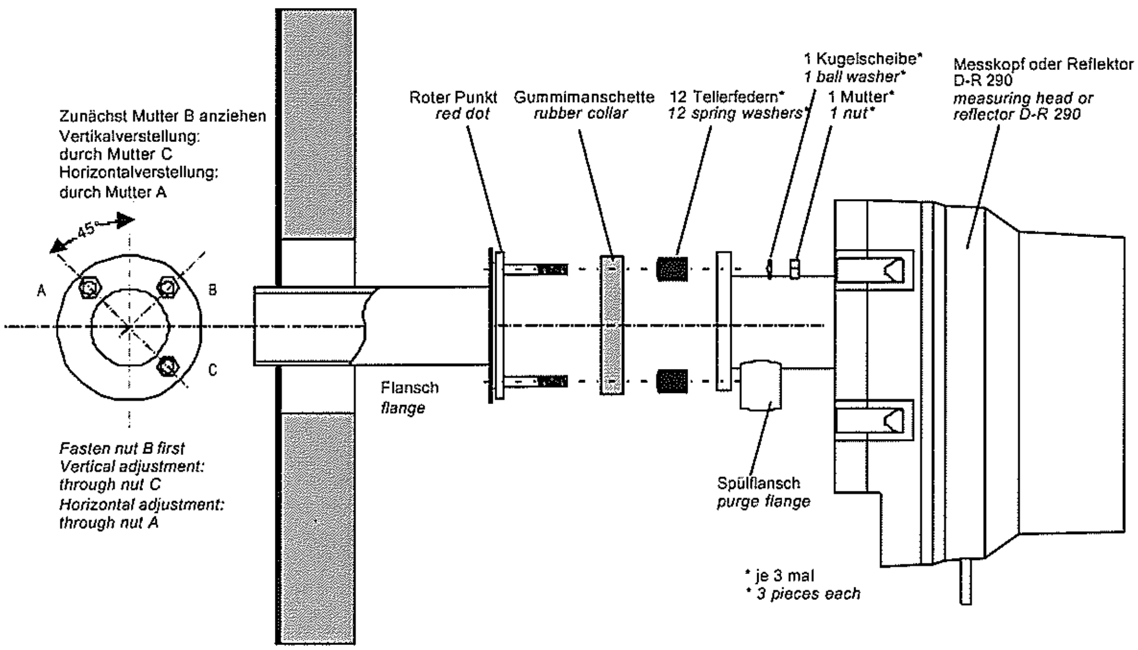
<table>
<tr><th>Display 10s digit</th><th>Digital Input 1</th><th>Digital Input 2</th><th>Digital Input 3</th><th>Digital Input 4</th><th>Digital Input 5</th><th>Digital Input 6</th></tr>
<tr><td>0 X S</td><td rowspan="7">Enable Programming
(close to change parameters)</td><td rowspan="7">Start Cal
Closed=no cal
Open=cal by timer
Upon opening =start cal</td><td rowspan="6">External Error 002
(Shutter, DP Cell)</td><td rowspan="6">Range 2 Output 1
Close to change analog output 1 to range 2</td><td rowspan="6">Range 2 Output 2
Close to change analog output 2 to range 2</td><td rowspan="6">External Error 003
(Shutter, DP Cell)</td></tr>
<tr><td>1 X S</td></tr>
<tr><td>2 X S</td></tr>
<tr><td>3 X S</td></tr>
<tr><td>4 X S</td></tr>
<tr><td>5 X S</td></tr>
<tr><td>6 X S</td><td>Zero check</td><td>Window</td><td>Upscale</td><td>Stack factor</td></tr>
</table>

Table 2C

3 Transceiver

3.1 Optical alignment

1. Set-up Transceiver and Reflector in a dust-free room to the exact measurement path distance. Make sure to provide appropriate allowances for the cone washers and fail-safe shutters. The transceiver and reflector flanges should be as close to parallel as possible. Clean the optical surfaces (exit windows) with a soft, optics-safe cloth.
2. Once the transceiver and reflector are mounted as shown in figure 3 below, tighten down the three nuts on the reflector flange. The three nuts on the transceiver can then be used to optically align the system. Tighten down the nut labeled "B" in figure 3 first. Nut "A" can then be used to change the vertical alignment of the transceiver on the B-C axis. Adjusting the "C" nut will change the transceiver alignment along the A-B, or horizontal, axis. Once the transceiver position is correct, loosen the metal thumb screw on the transceiver optics that secures the position of the focus adjustment. Use the plastic knob to adjust the focus. For path lengths between 1 and 2.25 meters, the monitor is correctly adjusted when the image is the sight is clear. For path lengths greater than 2.25 meters (7 feet), turn the knob to the counter-clockwise until it stops. Once focusing is complete, retighten the metal thumb screw on the optics to secure the focus.



(Fig. 3) Mounting on the adjustment flange

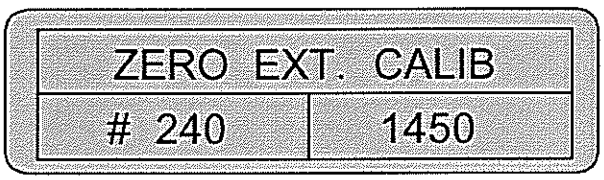
3.2 *Basic Adjustment of the Transceiver (Call Durag, Inc first)*

During basic set-up, the transmitting LED (intensity) is set. Any previously saved values for the system will be erased. A new clear path adjustment will need to be performed after the basic adjustment. Do not perform this procedure unless specifically directed by DURAG.

The basic transceiver set-up should be conducted as follows:

1. Set up the transceiver and reflector in a dust-free room (or use a measuring pipe) to set up the monitor to the maximum range of the reflector. Make sure the flanges on the transceiver and reflector are parallel. Clean the optical surfaces (exit windows) with a soft cloth designed for optics.
2. Next, open the four hasps on the transceiver head and swing it open. With a 4 mm allen wrench, remove the six screws that hold the cover in place. Close the transceiver and latch it shut with the hasps.
3. In the transceiver, push switches **S2** and **S3** into the "ON ↑" position, in the multiple switch **S4**, switch **S4/6** should be in the "OFF ↓" position and the three=position switch **S5** should be in the center (enabling data entry).
4. **Power up** the transceiver and AW controller (Plug St. 1).
5. Line 1 of the LCD display should read: **ZERO EXT. CALIB** .
6. Optically align the transceiver. (See page 8, Optical alignment)
7. Return switches **S2** and **S3** to the lower, OFF ↓ position, then push switch S5 toward the front of the monitor (for calibration cycles) until the yellow LED blinks. Return switch **S5** to the center position; the yellow LED should continue blinking for the rest of the basic set-up procedure. The red LED should be constantly lit, indicating that data entry is enabled. The LED current will be calculated against the external measurement path. The lower line of the LCD display should be working and segment four will display the LED current value. The displayed value should be between 700-1000. A value of 4000 corresponds to an LED signal of approximately 100 mA.
8. If **S4/6** on the **S4** switch is returned to the ON ↑ position *before the basic set-up is completed*, any previously recorded filter audit (linearity) data will not be erased.

Line 1 *Segment 1* *Segment 2*



Line 2 *Segment 3* *Segment 4*

9. After the LED current is set, the monitor will determine the amplification of the comparison normal light beam. The lower line of the display will be active and segment three will show the amplification factor. This should be between 10-50.

	Segment 1	*Segment 2*
Line 1	LED INT. CALIB	
Line 2	# 127	1450
	Segment 3	*Segment 4*

10. After the basic set-up is complete, a calibration cycle will run (the yellow LED will go out). To prevent any further changes to the monitor set-up, put switch **S5** to the back (the red LED will extinguish). On switch **S4** put **S4/6** in the ON ↑ position. If **S4/6** on the **S4** switch was already returned to the ON ↑ position before the basic set-up is completed, any previously recorded filter audit (linearity) data was preserved.

	Segment 1	*Segment 2*
Line 1	ZERO EXT. CALIB	
Line 2	* 0,0 %	4.00mA
	Segment 3	*Segment 4*

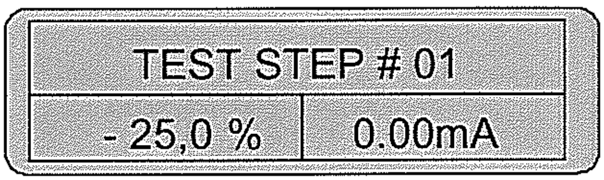
11. Once the basic set-up has been completed (the yellow LED will not be lit), disconnect the transceiver and controller (power off) and replace the cover with the six screws.

3.3 *Offset Calibration (Call Durag, Inc first)*

After the first basic set-up, the offset calibration must be run.

1. Switch **S2** should be in the ON position and switch **S6** should be in position **1**. The first line of the LCD display should read: **TEST STEP # 01**.
2. Press the **S7 +** key (see switch S6 test functions on page 22). This will toggle the transceiver head into comparison mode and the transmitting LED will be turned off. Te first line of the LCD display will alternate between the error message **** ERROR 50 **** (LED fault) and **TEST STEP # 01**.
3. Use potentiometer P1 to adjust the current at test point **MP 3** to read 20 mV, using capacitor C37 as ground (1000 ì F/ 25 V).

<u>Line 1</u> ***Segment 1*** ***Segment 2***



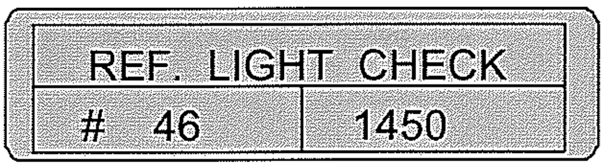
<u>Line 2</u> ***Segment 3*** ***Segment 4***

4. Put switch **S2** in the OFF position and switch **S6** in the 0 position.
5. Disconnect the transceiver and controller (power off) and **repeat the basic set-up** in page 9.

3.4 *Setting the Light Intensity of the Internal Zero Point Reflector*

1. The internal zero point reflector must be adjusted so that it reflects the light beam with the same intensity as the D-R 290 R reflector on a dust-free measuring path.
2. Set up the transceiver and reflector in a dust-free room to the exact path length at the installation site. Make sure to calculate the additional distance needed to account for the washers and fail-safe shutters. If the path length at the installation is unknown, use the maximum length for the reflector (2.25 m for reflector 1, 12 m for reflector 2).
3. Open the four hasps on the transceiver head and swing it open. Remove the six 4 mm hex screws and remove the cover. Close the transceiver head and refasten the hasps. Connect the transceiver head and controller (plug St. 1). Once turned on, the D-R 290 will run a self-check and the comparison light beam will be checked. Line 1 of the display should read: **REF. LIGHT CHECK**. After the system automatically sets the LED intensity, the unit can be adjusted (the yellow LED will go out).

<u>Line 1</u> *Segment 1* *Segment 2*

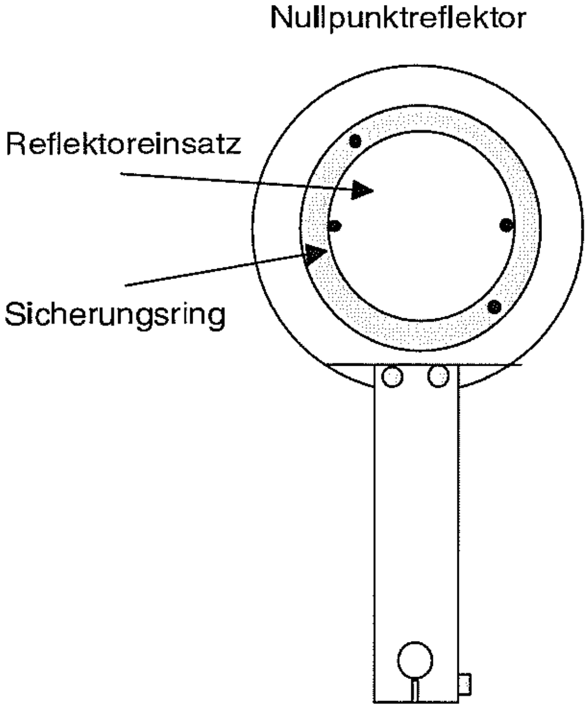


<u>Line 2</u> *Segment 3* *Segment 4*

4. For this calibration, push switch **S2** on the D-R 290 MK number 20 board into the upper **ON ↑** position, and the service switch **S6** in the test function 4 position. Press the **S8 —** key to bring the reflector into position on a dust-free path (clear-path). Measure the signal at test jack MP.2 (external zero point) to the ground on the C37 (1000 ì F / 25 V) capacitor.
5. Press the **S7 +** key to bring the internal zero reflector into position and measure the voltage at the MP.2 test jack. The internal zero point reflector must be adjusted to have the same light intensity (current) that was measured with the external zero point reflector (max. tolerance: 5).
6. To run he calibration, loosen the ring on the zero point reflector that locks its position (turn to the left). The reflector can be calibrated by rotating the reflector insert. Turning to the right will reduce the light intensity and give a lower current reading. Turning to the left will increase the light intensity and yield a higher current. When the measured signal for the internal zero reflector is the same as the signal measured for the external

reflector, tighten the locking ring on the reflector insert by turning it to the right. ***After you are done with the adjustment return the switches.***

7. Run the clear path calibration procedure from page 12 starting at paragraph 3.



(Fig. 4) Internal Zero Point Reflector

3.5 Clear path procedure

The clear path procedure should be run in the following order:

1. Set up the transceiver and reflector in a dust-free room to the exact path length of the stack where they will be installed. Make sure to include the appropriate allowances for the disk washers and fail-safe shutters. Clean the optical surfaces (exit windows) with a soft, optics-safe cloth.
2. Open the four hasps on the transceiver and swing the housing open. With a 4 mm allen wrench, remove the six screws that secure the cover and remove it from the housing. Swing the transceiver head closed. Supply power (connect plus "St1") to the transceiver and the D-R 290 AW controller. Once turned on, the D-R 290 will run a self-check cycle and check the value of the comparison light beam. The LCD display will read: **REF. LIGHT CHECK** on line 1. Once the automatic start-up has been completed and LED intensity has been set, the system can be calibrated (the yellow LED will go out).

Line 1	*Segment 1*	*Segment 2*
	REF. LIGHT CHECK	
	# 146	1450
Line 2	*Segment 3*	*Segment 4*

3. Put switches **S2** and **S3** in the upper, "**ON ↑** " position, Display line 1: **ZERO EXT. CALIB** .
4. Optically align the transceiver head.
   (see page 8, Optical alignment)
5. Return switches **S2** and **S3** to the lower, "OFF ↓" position, the press switch **S5** (towards the front of the monitor). Switch **S5** can then be moved back to the center position, at which point the yellow LED should continue blinking and the red LED should be continuously lit. The lower line of the display (on the AW controller) should be working.
6. Display line 1: **LED INT. CALIB** the comparison light beam is calibrated.
7. Display line 1: **ZERO POINT CALIB** the internal zero point value is calibrated.
8. Display line 1: **SPAN CALIB** The reference light path is calibrated.
9. Display line 1: **ZERO EXT. CALIB** the external zero point value is calibrated.
10. After the clear path calibration procedure, the system will run a self-check again, indicated by the blinking of the yellow LED. To allow these new clear path values to be saved, switch **S5** must be pushed back (the red LED will go out).
11. Disconnect the power to the transceiver head and the AW controller. Loosen the 4 hasps on the transceiver head, swing open the transceiver, and replace the lid to the housing, making sure to secure all six screws. The transceiver head can then be closed and the hasps fastened again.
12. Reconnect the transceiver and AW controller (supply power). When the D-R 290 is turned back on, the system will again run a self-check cycle.

3.6 *Manual calibration of the internal zero point (Window Check)*

If the internal zero point value still requires adjustment after the automatic calibration procedure, this calibration can also be initiated manually.

1. Clean the optical surfaces (exit windows) with a soft, optics-safe cloth. Using the "MOD" and "**+**" keys on the D-R 290 AW controller, select the "Window Check" measurement.
2. On the D-R 290 MK No. 20 board in the D-R 290 MK transceiver, switch **S4/4** on the 6-slot switch block #**4** should be set to the "OFF ↓" position, and switch **S3**, which controls the calibration cycle, should be in the "ON ↑" position. Switch **S5** must be positioned to enable data entry (center position), as indicated when the red LED is lit. The first line of the LCD display should alternate between OFFSET -- + and WINDOW CHECK.
3. With the **S8** [-] key (decrease displayed value) and the **S7** [+] (increase displayed value), the internal zero point can be corrected to 4.0 mA. It is important, however, to ***remember that the internal zero point is calculated over a 10 second integration time.*** Using the S7 and S8 keys briefly best makes this adjustment, and then waiting ten seconds to view the changes after the integration time has passed. If the value is still not correct, repeat this process as necessary. As long as one of these keys is pressed, the yellow LED will light.
4. Once the calibration is complete, return the switches to there default positions: **S5** locked (the red LED goes out), switch **S4/4** on **#4** should be in the ON ↑position. Switch **S3** should be in the OFF ↓ position. Replace the cover and tighten the mounting screws.

3.7 *Manual Calibration of the External Zero Point (Call Durag, Inc first)*

If the external zero point value still requires adjustment after the automatic calibration procedure, this calibration can also be initiated manually.

1. Set up the transceiver and reflector in a dust-free room (or use a measuring pipe between the heads) to the exact path length of the stack where they will be installed. Make sure to include the appropriate allowances for the disk washers and fail-safe shutters. Clean the optical surfaces (exit windows) with a soft, optics-safe cloth. Select a short integration time, such as 8 seconds, on the D-R 290 controller and then choose "External Zero".
2. On the D-R 290 MK No. 20 board in the D-R 290 MK transceiver, switch **S4/5** on the 6-slot switch block **#5** should be set to the "OFF ↓" position, and switch **S3**, which controls the calibration cycle, should be in the "ON ↑" position. Switch **S5** must be positioned to enable data entry, as indicated when the red LED is lit. The first line of the LCD display should alternate between OFFSET - + and OUTPUT X.
3. With the **S8** [-] key (decrease displayed value) and the **S7** [+] key (increase displayed value), the external zero point can be corrected to 4.0 mA. It is important, however, to remember that the external zero point is calculated over an integration time. Using the S7 and S8 keys briefly best makes this adjustment, and then waiting a few seconds to view the changes after the integration time has passed. If the value is still not correct, repeat this process as necessary. As long as one of these keys is pressed, the yellow LED will light.
4. At the end of the calibration, return the switches to their default positions.

3.8 Checking the linearity on the path length (EPA filter audit)

Set the D-R 290 to a short integration time and select the value (external zero point) that will be tested. The display should read **OUTPUT 1**.

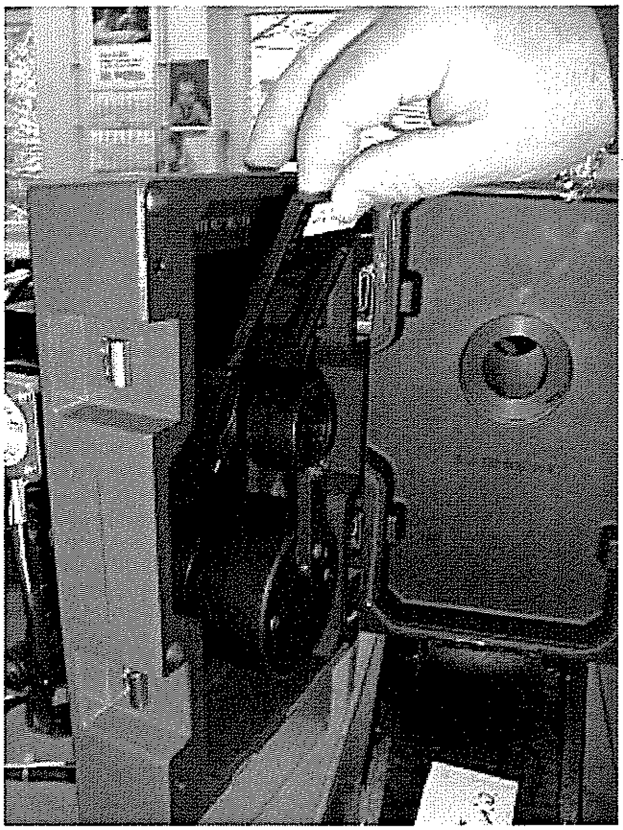
Testing according to EPA regulations.

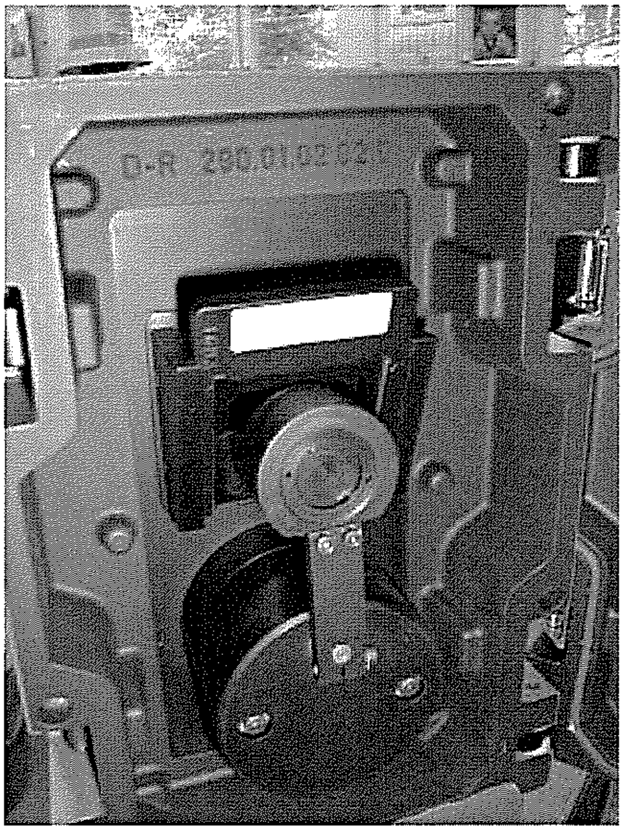
The linearity of measurements in the measurement range from 0-100% with a stack correction factor of 1.000 are tested. A filter holder should be set-up at the midway point of the measurement path angled at less than 10-15°. During testing, the monitor should read within ± 1.5 % of the standard value for the filter. If the linearity needs to be recalibrated, follow the procedure on 18, EPA filter audit test (linearity calibration).

3.9 Filter audits in the control mode

Die The control mode also allows for filter audit testing to EPA regulations. The testing should be run using the output 1 measuring range. This test will measure the OP measuring range with a stack correction factor of 1.

(Fig. 5) EPA – Test filter





After selecting the control mode (display: **CONTROL MODE**), press the STO key to run a window contamination check and bring the display to 4 mA, if needed. Open the hasps on the transceiver head and swing it open. The unit is now ready for filter audit testing. A special holder has been built into the transceiver to hold the calibration filters, (see illustration above. During testing the, the monitor should read the standard value of the filter within ± 1 %. If these values are not linear, repeat the procedure on 18, EPA filter audit test (linearity calibration).

3.10 Testing the reference filters

Select the span / reference value check, (the display should read **SPAN CHECK**) from the D-R 290 AW controller. If the span value is approximately 71%, this value should be recalibrated, as described on page18, EPA filter audit test (linearity calibration).

3.11 EPA filter audit test (linearity calibration) {Call Durag. Inc first}

Select the desired value on the D-R 290 AW controller. For the linearity calibration for the external zero (OUTPUT X), select a short integration time.

1. After opening the cover of the D-R 290 MK transceiver, put switch **S3** (calibration function) into the ON ↑ position. Switch **S5** must be set to enable data entry and the red LED should be lit to indicate this. On the 6-throw switch **S4**, put the switch for the value to be calibrated into the OFF ↓ position, as indicated in the table below.

S4/1	**OUTPUT X**, (current measured value „ External Zero Point “)
S4/2	**CONTROL MODE**, (EPA filter audit test)
S4/3	**SPAN CHECK**, (Internal Reference Filter)

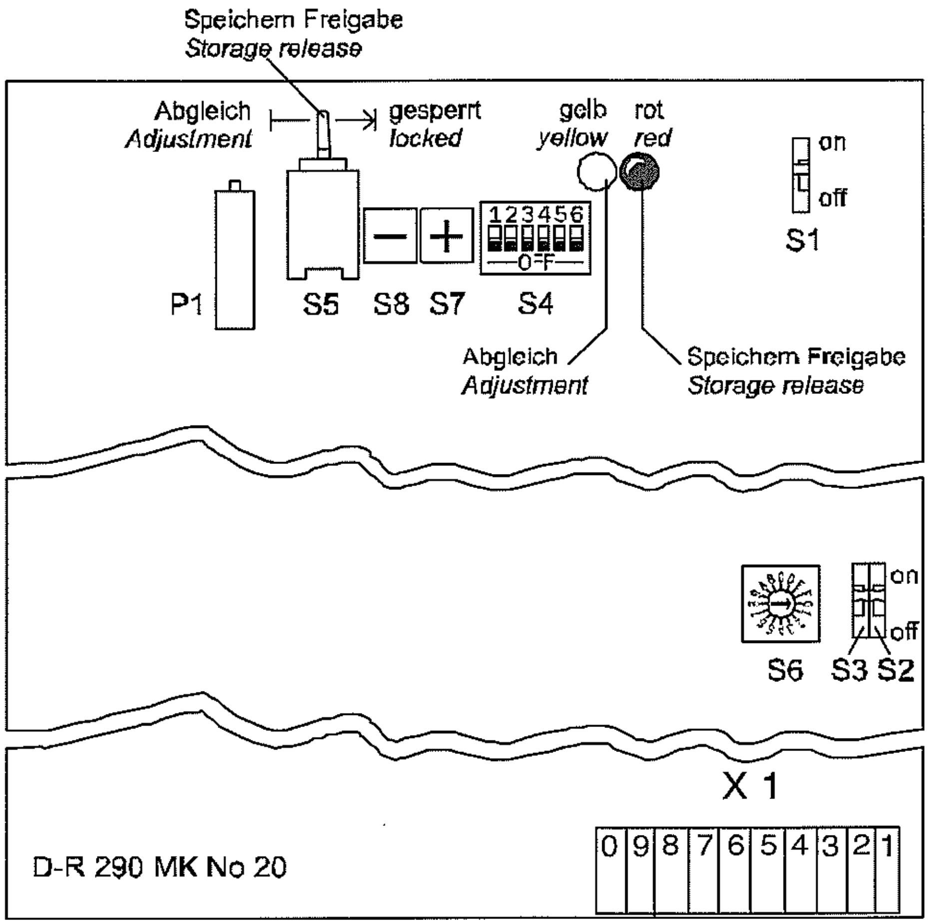
2. The first line of the display should alternate between **Slope -+** and the value to be adjusted <u>when the measured value is greater than 4.00 mA.</u>

3. With the **S6** [-] (decrease displayed value) and **S7** [+] (increase displayed value) keys, the slope can be corrected to match the value of the test filter. Make sure to allow for the selected integration time to make sure the desired value has been set. Make sure to press the keys briefly then wait out the integration time before pressing the keys again. While the **S6** and **S7** keys are pressed, the yellow LED will light if the <u>measured value is greater than 4.00 mA.</u>

4. After the adjustment, return the switches to orginal default positions: **S5** locked with the red LED extinguished, **S3** in the OFF ↓ position. Replace the cover and tighten the mounting screws. Reset the integration on the D-R 290 AW controller and save the value.

5. Disconnect the transceiver and controller (power down). Open the four hasps on the transceiver head, swing it open, and replace the cover. Close the transceiver and the hasps.

Reconnect the transceiver and controller (and supply power). Once turned on, the D-R 290 will run a control cycle: for 1:30 minutes each, the D-R 290 will determine its internal zero point, window check, and reference point values (displayed in %).



(Fig. 7) Location of Switches in the Transceiver Head

3.12 Transceiver Head Switch Functions

Switch S1

ON	OFF	Default Setting
X		Watch Dog Timer **ON**

Switch S2 and S3

	ON	OFF	Function
S2		X	**Default Setting**
S3		X	**Default Setting**
S2	X		Enables a calibration cycle start using switch S5
S3	X		Enables a calibration cycle start using switch S5
S2	X		Enables the use of the service program switch S6
S3	X		Enables the start of a calibration function using switch S4

DIL- Switch S4

S4	ON	OFF	Default settings
6	X		Basic configuration/ calibration disabled
5	X		OFFSET External zero point (measurement)
4	X		OFFSET Internal zero point (Window Check)
3	X		SPAN Slope
2	X		CONTROL MODE Slope
1	X		OUTPUT Slope

Switch S5

Switch S5	Function	
Press switch in:	Start Calibration Cycle	Yellow LED blinks
Center position	Enable data/parameter entry	Red LED is lit
On position	Disable data/parameter entry Default **Setting**	Red LED is not lit

3.13 *Changing the EPROM's*

D-R 290 AW

After replacing the EPROM chip (IC D6 on the D-R 290 AW number 30 board), the following steps should be taken. Make sure switch **S5** is in the "OFF" position and the status relays (enable programming) are closed (Plug2 2D to 2Z is shorted). When the system is powered up, the default settings will be loaded and saved over any existing parameters. The display should show '**System Status ->**", after which switch **S5** should be returned to the "ON" position. **You will need to reprogram your mode and all the setting on the D-R290AW.**

D-R 290 AZ

If you replace the EPROM chip (IC D6 on the D-R 290 AZ number 30 board) there is no set-up procedure required. Just reinstall the unit and make sure it is working right.

D-R 290 MK

When the EPROM is replaced (IC D9 on the D -R 290 MK number 20 board) a basic adjustment maybe required, this also needs to be done if the number 20 board is replaced with a new board. {**Call Durag, Inc. first** }

After the basic adjustment a clear path and filter audit test will need to be preformed.

3.14 Test function (Switch S6)

To call up the test function, put switch **S2** on the D-R 290 MK No 20 board into the upper ON ↑ position and select the desired test function with service switch **S6** as shown in the table below. Use keys **S8 --** and **S7 +** to initiate the test step.

Watch Dog Timer Test

For test step 09, the watchdog timer must still be active, that is switch **S1** should be in the OFF ↓ position. Pressing **S8 --** or **S7 +** keys will deactivate the watchdog timer so it doesn't trip. The transceiver will restart the program. The program start begins by checking the comparison light beam. The first line of the display will read: **REF. LIGHT CHECK.**

Switch S2	Switch S6	Key " - " S8	Key " + " S7	LCD – Display, Line 1
ON	**0**			**TEST STEP # 00**
ON	**1**	External zero LED ON		**TEST STEP # 01**
ON	**1**		Comparison LED OFF	**TEST STEP # 01 ERROR 50**
ON	**2**	External zero	Comparison	**TEST STEP # 02**
ON	**3**	External zero	Reference value	**TEST STEP # 03**
ON	**4**	External zero	Internal zero	**TEST STEP # 04**
ON	**5**	Internal zero	Comparison	**TEST STEP # 05**
ON	**6**	EE Prom	Test	**TEST STEP # 06**
ON	**7**	E Prom	Test	**TEST STEP # 07**
ON	**8**		Transceiver fault	**TEST STEP # 08 ERROR 70**
ON	**9**	**Watchdog**	**Timer**	**TEST STEP # 09**

4 Circuit Board Installation

4.1 Installing a new D-R 290 MK No. 20 board

Disconnect the transceiver and controller from the power supply. Open the four hasps on the transceiver head and swing it open. With a 4 mm Allen wrench, remove the mounting screws that secure the cover and remove it.

1. On the D-R 290 MK No. 20 board, pull plugs X1 through X4 from their sockets.
2. Remove the three screws that secure the circuit board. Put the new circuit board in place and secure it with the three screws.
3. Check the operating voltage. Connect the transceiver and the controller and power them up. Check the voltage at socket **X1**. The tolerance of the 15 Volt line is ±5%, and the tolerance for the +5 Volt current is +5%.
4. Connect the transceiver and controller and connect sockets X1 to X4 with the pins on D-R 290 MK No. 20 board.
5. Power up the transceiver and controller and test the current on the right most pin of the voltage **N1 = +12V**, **N2 = -12V** and **N3 = +5V** (tolerance ± 5 %) against the ground of the C 37 capacitor (1000 ì F / 25 V).

After changing the circuit board, run the following procedure:

6. Basic configuration of the transceiver (see Page 9).
7. Offset calibration (see Page 11).
8. Set the light intensity of the internal zero point reflector (see Page 12).
9. Clear path calibration procedure (see Page 14).
10. Filter audit / linearity test (see Page 18).

4.2 Changing the EPROM (D-R 290 MK controller) (Call Durag, Inc. first)

After installing a new EPROM chip (IC D9 on the D-R 290 MK number 20 board), the following procedures must be run:

1. Basic transceiver configuration (see Page 9).
2. Clear path calibration procedure (see Page 14).
3. Linearity calibration / EPA filter audit test (see Page 18).

4.3 Changing the LED

Disconnect the DR 290 MK transceiver and the D-R 290 AW control panel (power down). Open the four hasps on the transceiver head and swing it open. With a 4 mm Allen wrench, take out the six screws on the lid and remove it.

1. On the D-R 290 MK number 20 board, pull the 2-pin LED connector (socket X2) from the plug. Unscrew the three setscrews on the LED assembly.
2. Remove the old LED-assembly and put the new one in place (make sure to match the positions of the screws) and tighten all three Allen screws. Reconnect the 2-pin LED connector (socket X2 with the plug on the D-R 290 MK number 20 board.

After changing the LED, the following procedures need to be run:

1. Clear path calibration (see Page 14).
2. EPA filter audit test / linearity (see Page 18).

5 Plug X 1 Wiring Plan

Connection to D-R 290 MK transceiver					
D-R 290 AW Controller		Transceiver cable connections			
Plug	Contact	Plug	Wire Number	X1 Terminals	Function
St. 1	32 D Z	Housing	Shield		Shielding
St. 1	12 D Z	B	1	**1**	**+ 15 Volt**
St. 1	32 D Z	D	2	**2**	**GND**
St. 1	14 D Z	C	3	**3**	**- 15 Volt**
St. 1	2 D Z	A	4	**4**	**+ 5 Volt**
St. 1	32 D Z	E	yellow / green	**5**	**Earth ground**
St. 1	32 D Z	F	6	**6**	**GND**
St. 1	8 D	J	7	7	RS 422 < --
St. 1	8 Z	H	8	8	RS 422 < --
St. 1	6 D	G	9	9	RS 422 -->
St. 1	6 Z	M	10	10	RS 422 -->

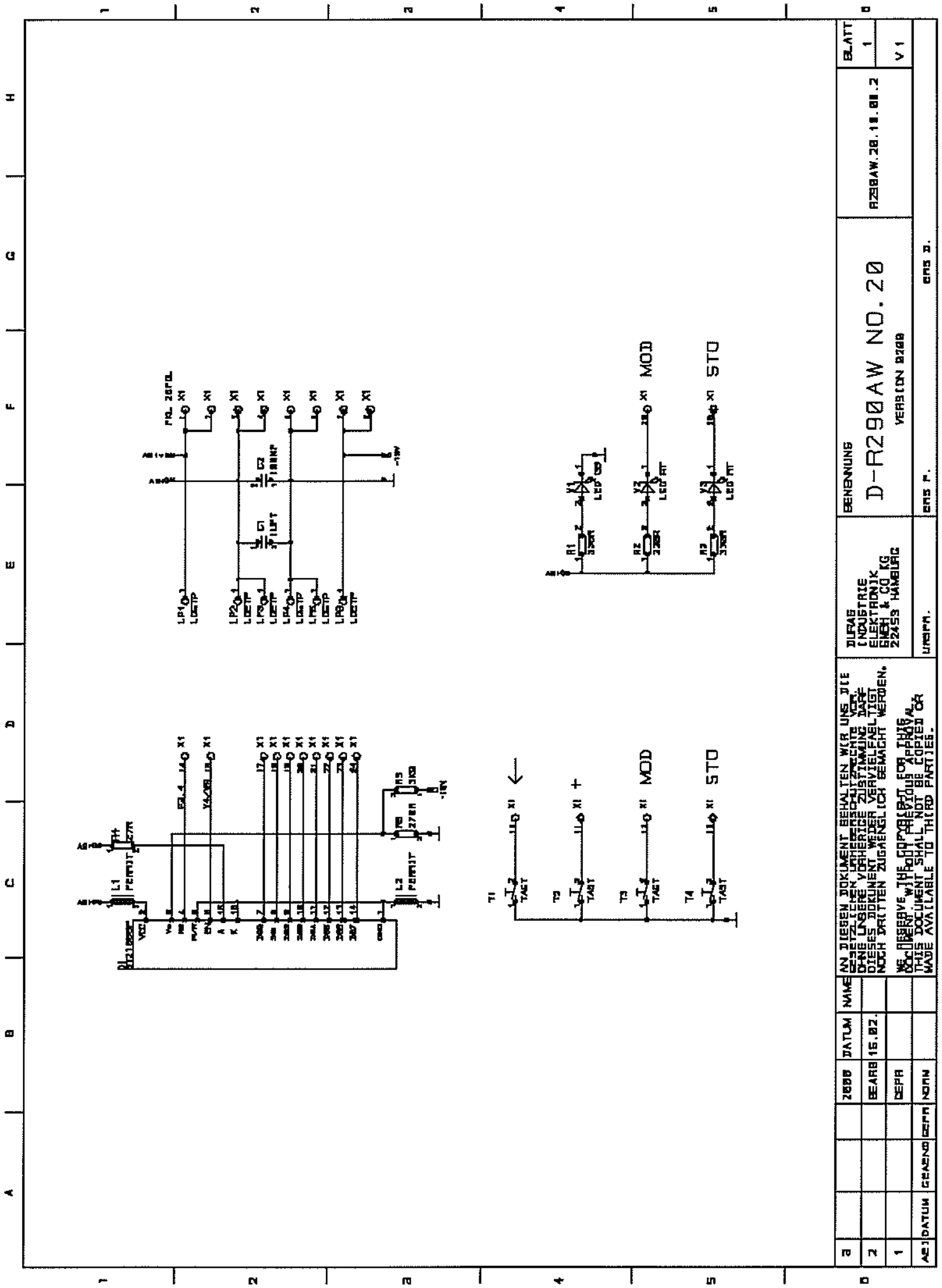
6 Plug X4 Wiring Plan

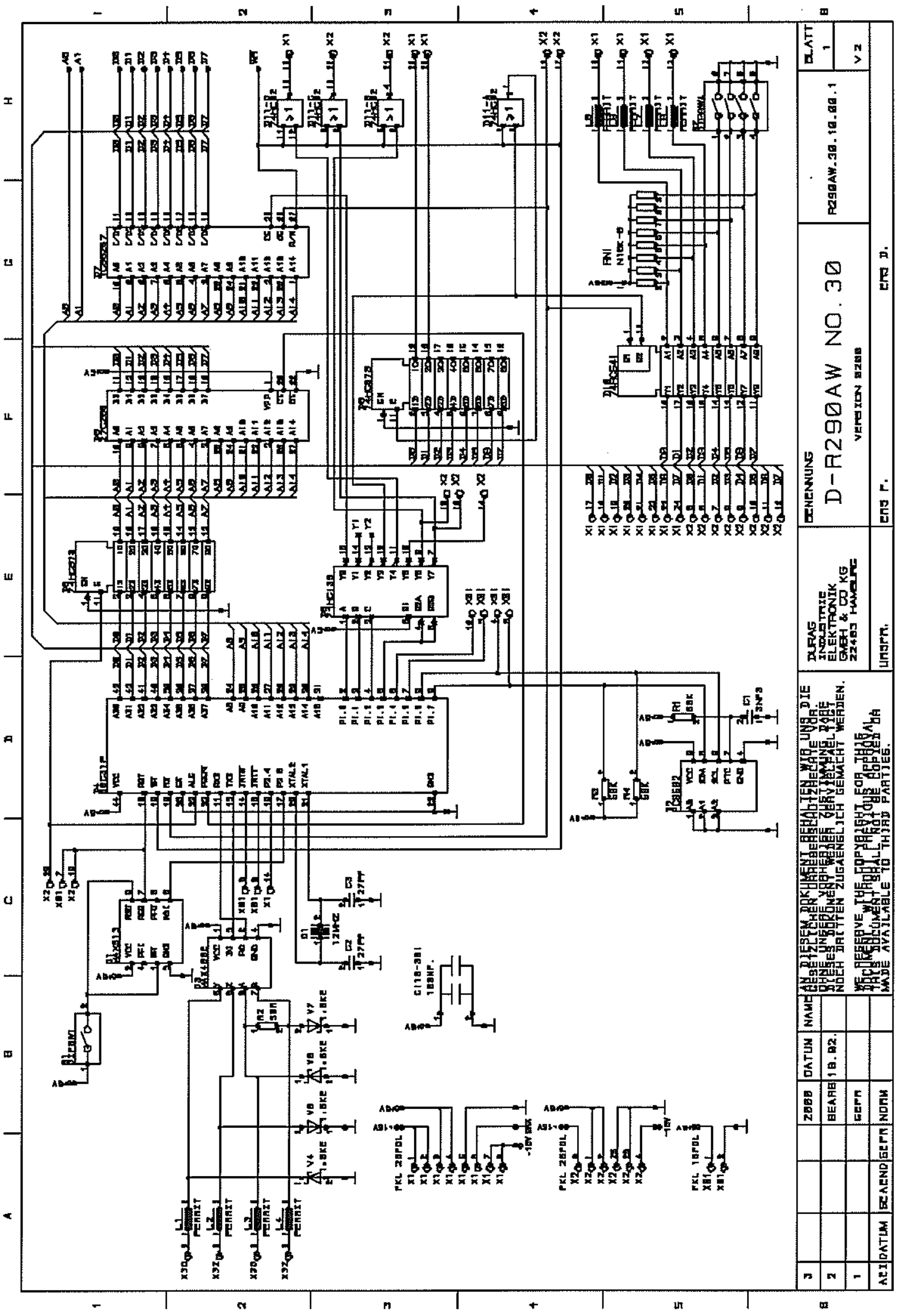
	Zero point Motor	Plug X 4		Comparison Motor	
	yellow	A 1	B 1	yellow	
	black	A 2	B 2	black	
	green	A 3	B 3	green	
	red	A 4	B 4	red	
	blue	A 5	B 5	blue	
	white	A 6	B 6	white	
Light box output	yellow	A 7	B 7	yellow	Light box output
Light box Ground	black	A 8	B 8	black	Light box ground
Light box + 15 Volt	red	A 9	B 9	red	Light box + 15 Volt
Heated exit window	black	A 10	B 10	black	Heated exit window

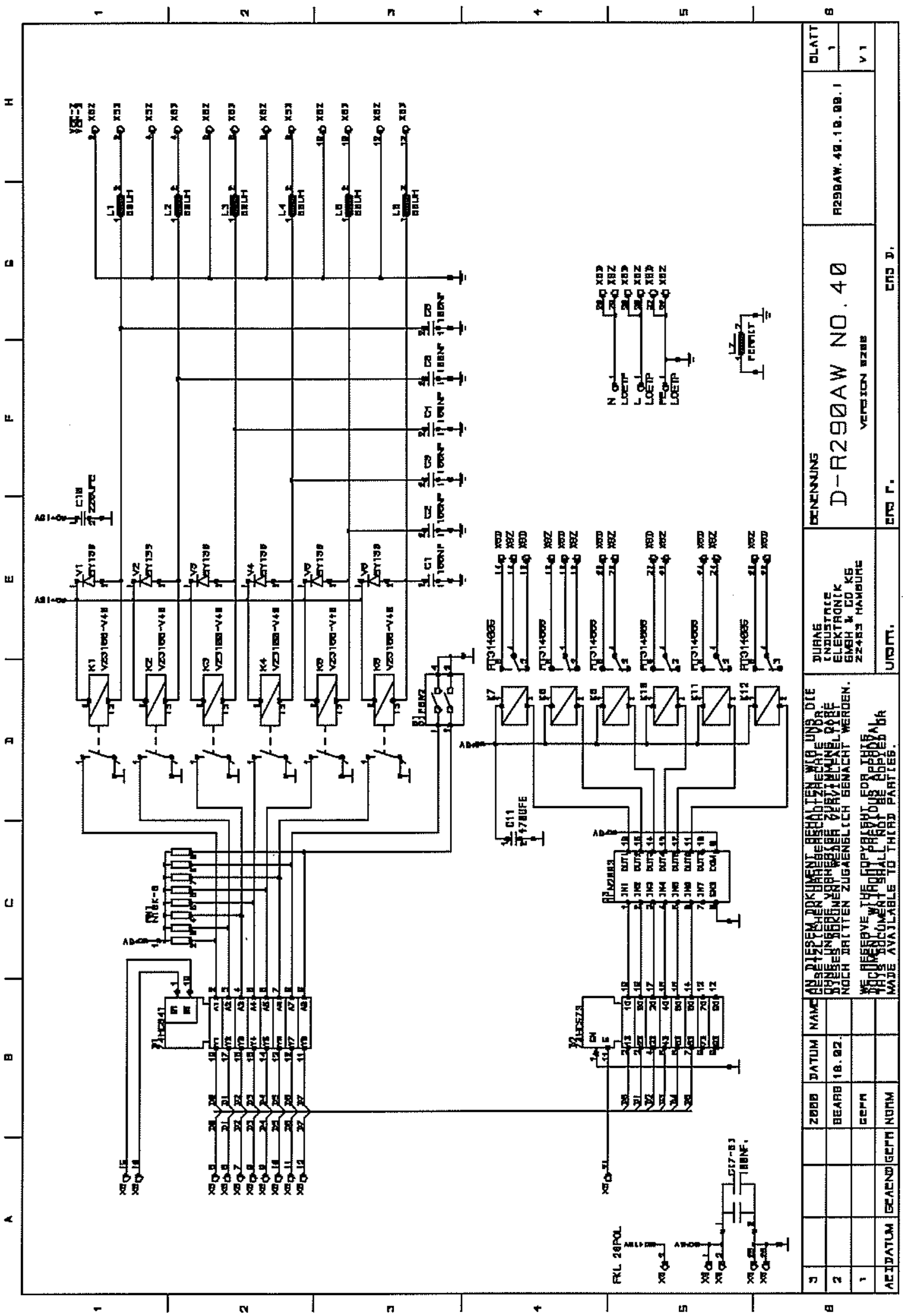
7 Recommended Spare Parts

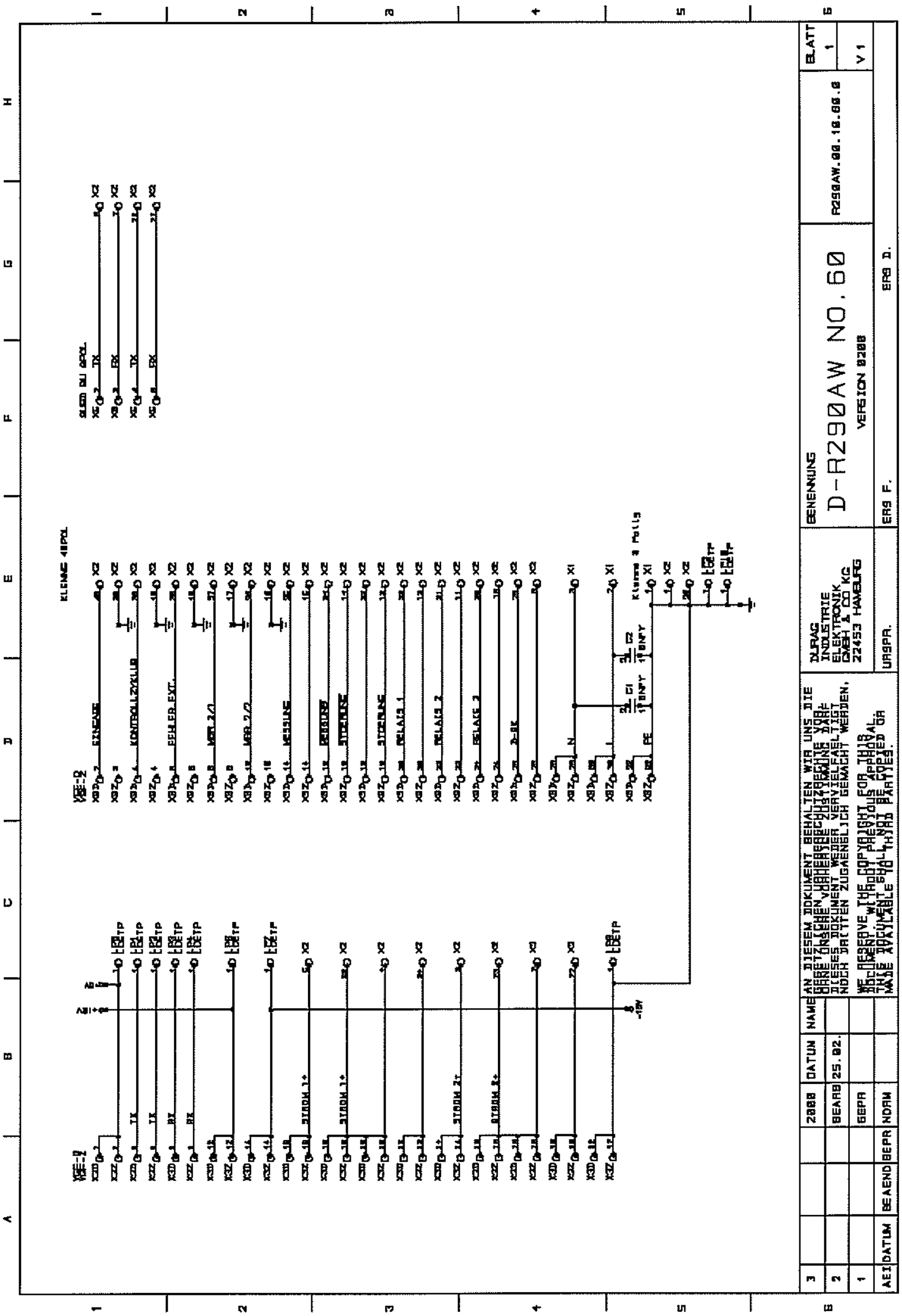
Part Number	Description
	Mounting
	Measuring Head / Reflector
	Super Wide Band Diode
	Main board
	PC board with light barrier
	Photo element with PCB
	Fuse A, per 10 pcs. (mains: 230V)
	Fuse A, per 10 pcs. (mains: 115V)
	Heated Disk
	Internal Zero Point Reflector
	Stepper Motor
	Reflector Insert Type I (1.0 - 2.25 m)
	Reflector Insert Type II (1.75-12.0 m)
	Control Unit
	CPU Board
	Relay Board
	Display / Data Entry
	Internal Back plane
	External Back plane (in wall mount housing)
	Power supply
	Purge Air Unit
	Filter Housing FPG05 7505
	Filter Cartridge P77-5308 for FPG05 7505
wdiluftsch280	Air Hose for blower, price per foot, diam. 50 mm
	Accessories

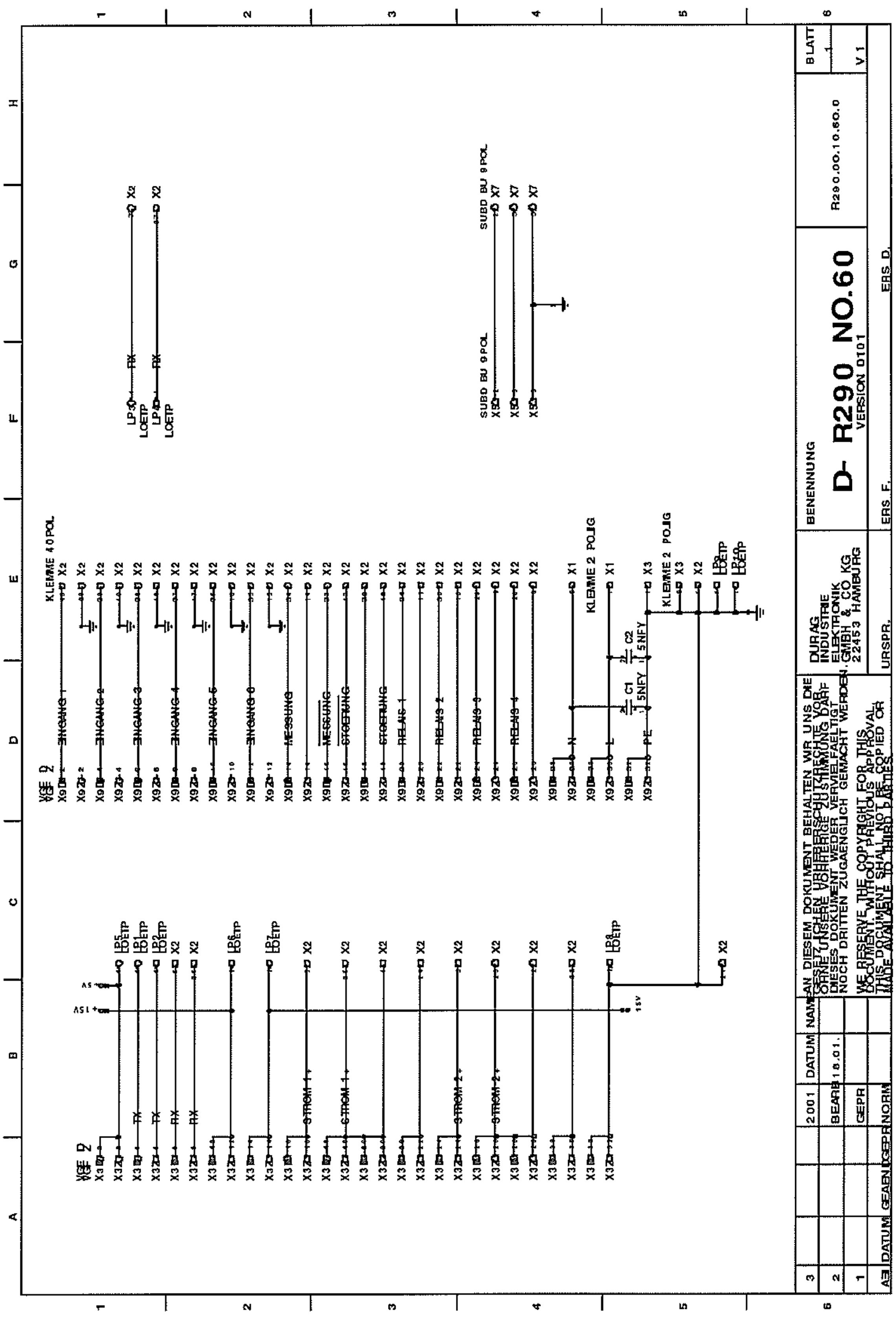
8 Schematics

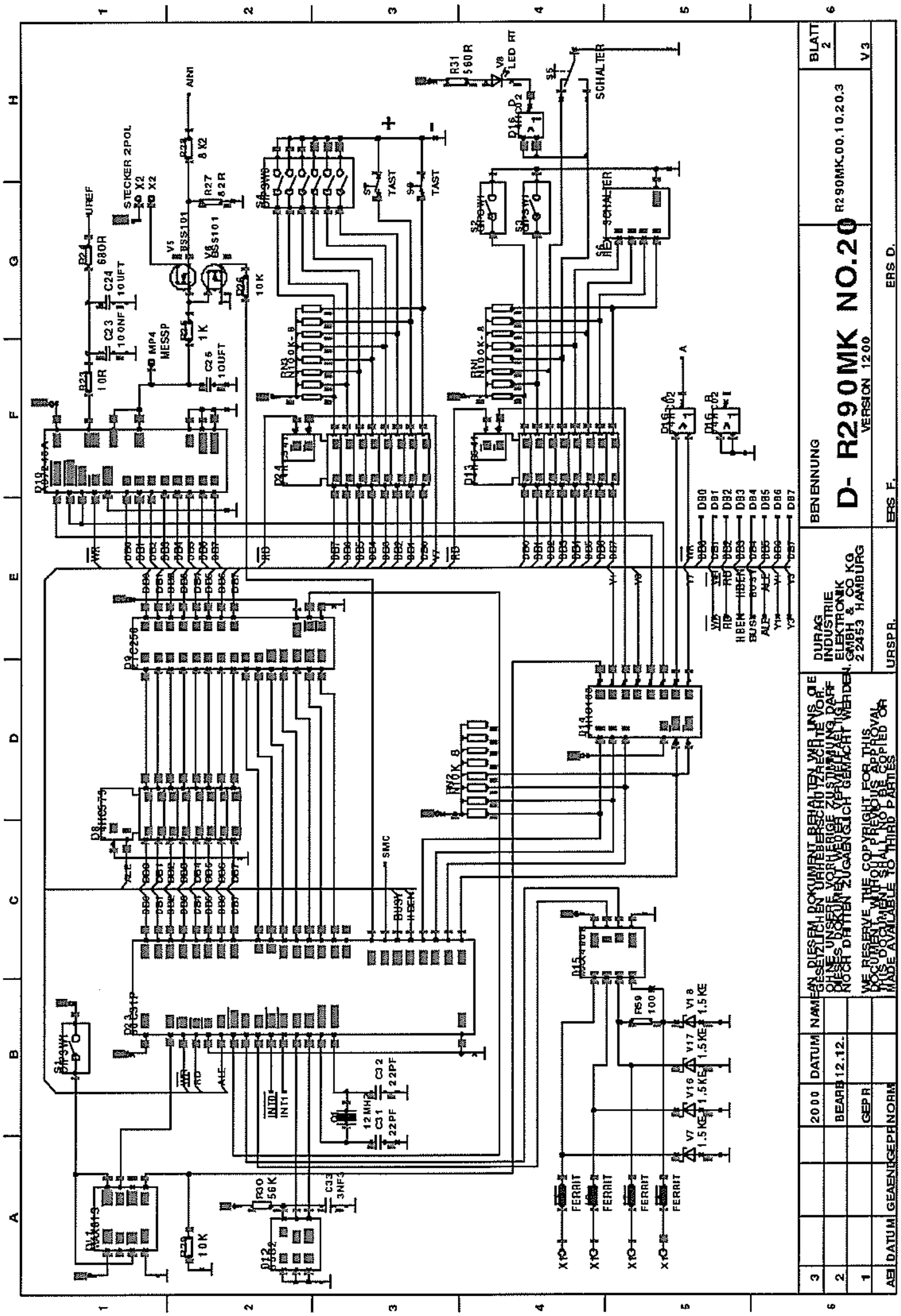


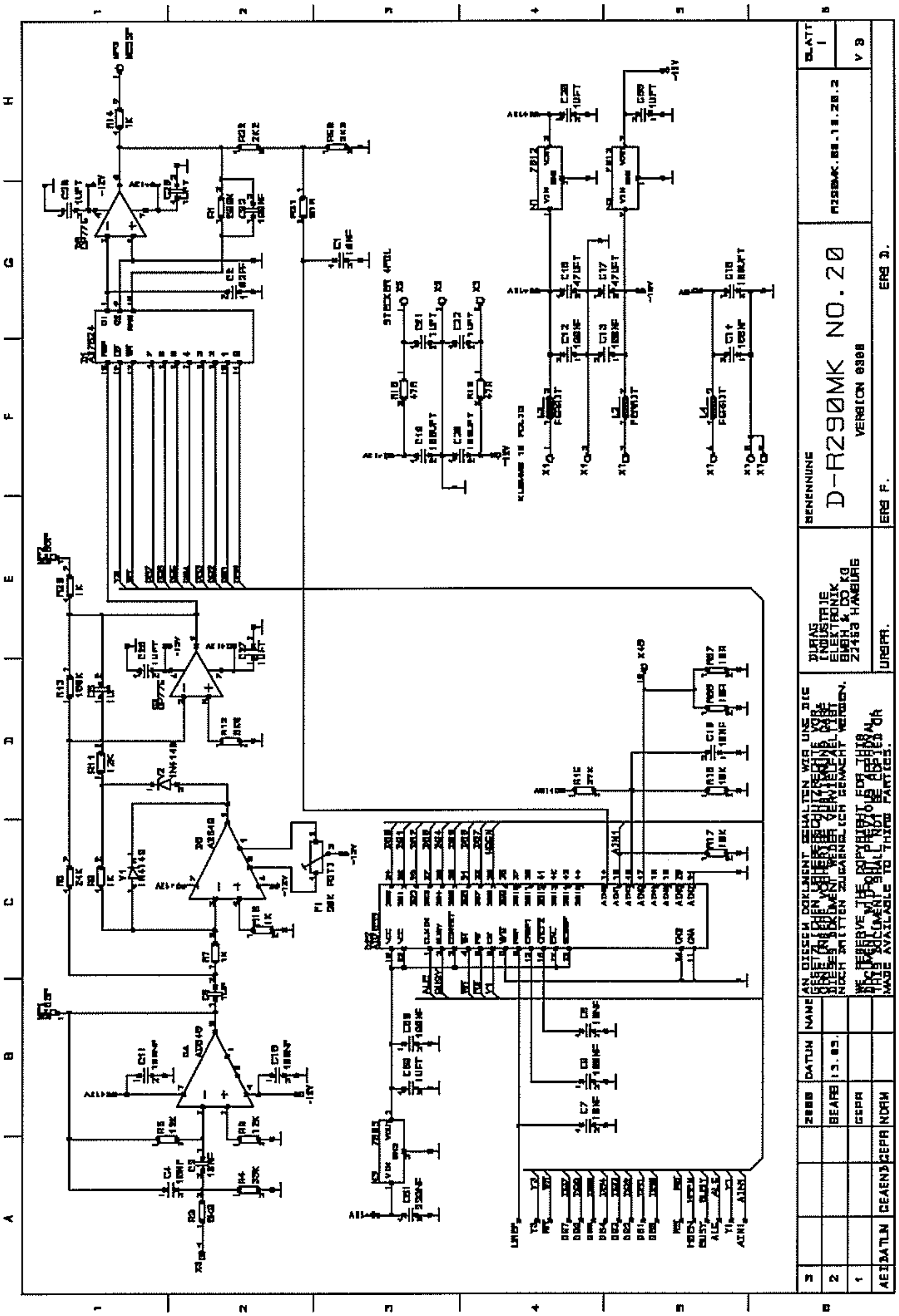

BENENNUNG
D-R290AW NO. 30
VERSION 8200
DURAG
INDUSTRIE
ELEKTRONIK
GMBH & CO KG
22453 HAMBURG
R290AW.30.10.00.1
BLATT
1
V2

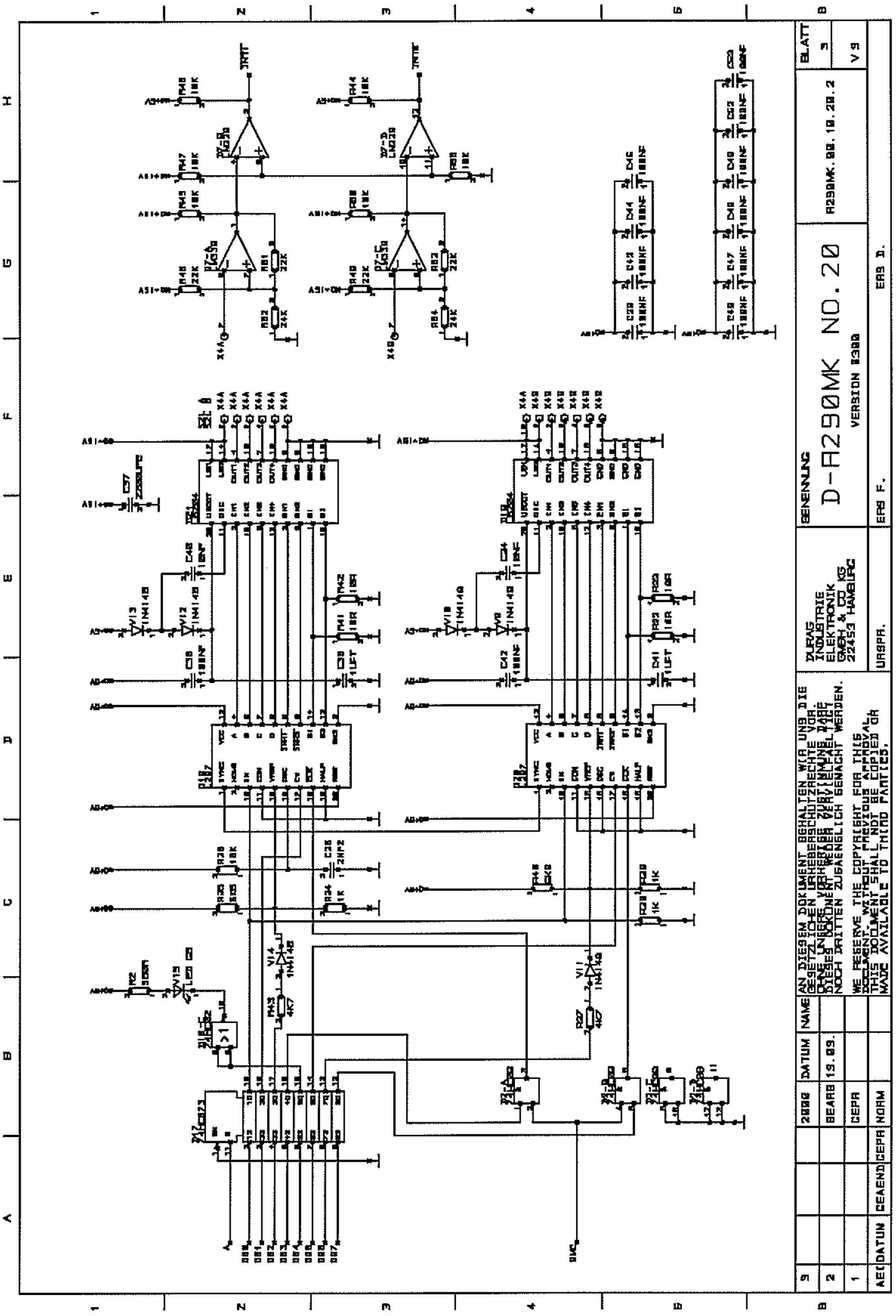

D-R290AW NO. 40
DURAG
INDUSTRIE
ELEKTRONIK
GMBH & CO KG
22453 HAMBURG

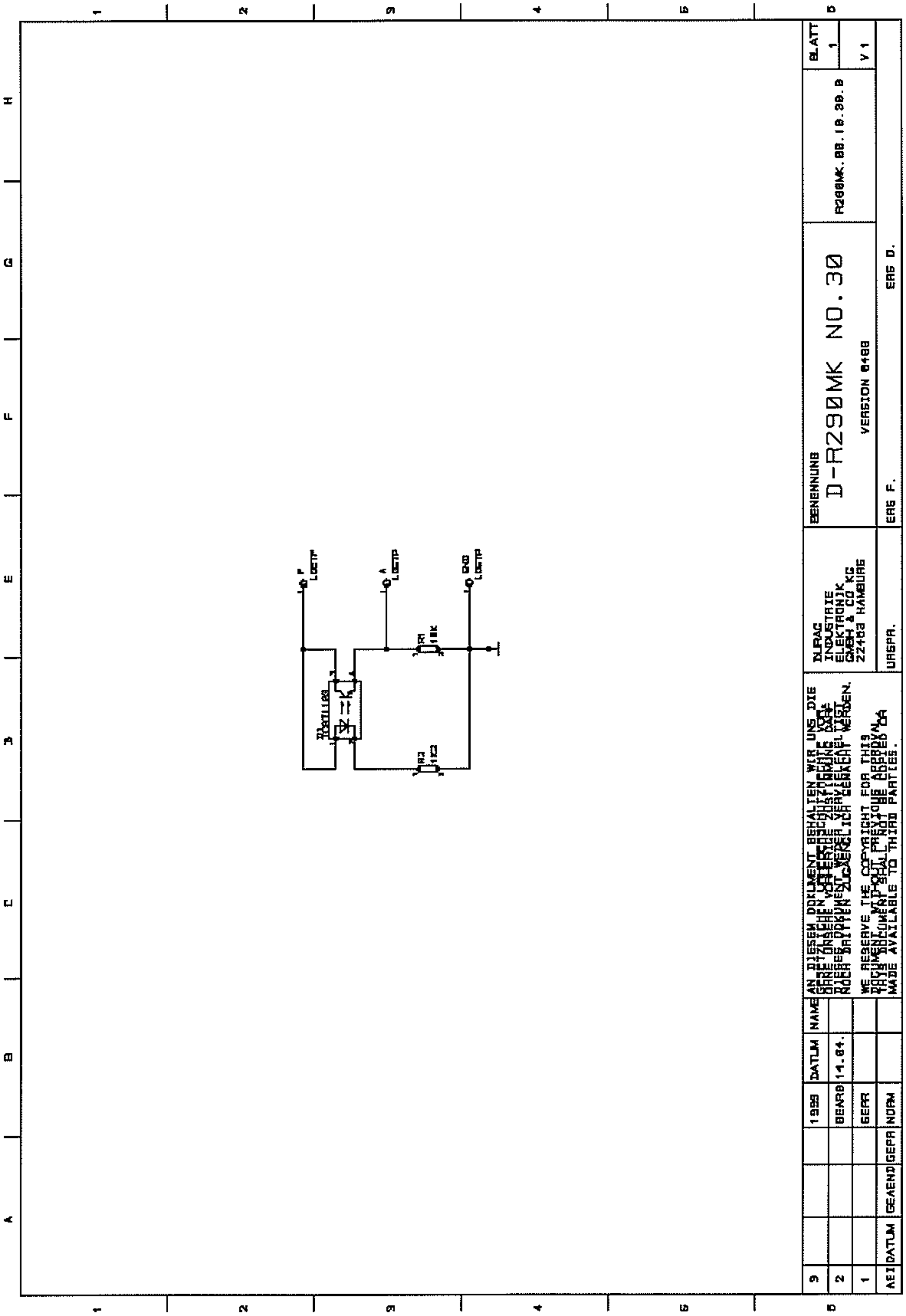

D-R290AW NO.60
VERSION 0208


BENENNUNG
D- R290 NO.60
VERSION D101
DURAG
INDUSTRIE
ELEKTRONIK
GMBH & CO KG
22453 HAMBURG
R290.00.10.60.0
BLATT
V 1


BENENNUNG
D- R290MK NO.20
VERSION 1200
R290MK.00.10.20.3
BLATT 2
V3
DURAG
INDUSTRIE
ELEKTRONIK
GMBH & CO KG
22453 HAMBURG
WE RESERVE THE COPYRIGHT FOR THIS DOCUMENT. WITHOUT PREVIOUS APPROVAL THIS DOCUMENT SHALL NOT BE COPIED OR MADE AVAILABLE TO THIRD PARTIES
URSPR.
ERS F.
ERS D.
SCHALTER
TAST
FERRIT


D-R290MK NO.20
VERSION 0308




D-R290MK NO. 30

9 Notes

SECTION 2.0

DUST COLLECTOR
OPERATION AND MAINTENANCE
PROCEDURES

Particulate Matter Control Device Requirements

1. **Specifications:**

- All particulate matter control devices shall meet an emission rate at or less than an outlet grain loading of 0.02 grains / $ft.^3$ of air.
- Particulate matter control devices shall be of the Jet-Pulse design with the following features:
  - Self cleaning with high pressure pulse jets of air.
  - Top bag removal.
  - Snap-in bags.
  - Cartridge type filters.
  - Self-supporting cages with integral venturi nozzles.
  - Timer for cleaning individual rows of bags.
  - Double tipping valves and rotary air locks at dust hopper outlet.
  - Differential pressure transmitters for on demand bag cleaning.
  - Noise level less than or equal to 85db at a distance of 3 ft.
  - Service platform and caged ladder when needed.
- All piping shall meet the following:
  - Air flow velocities shall be between 3500 – 4000 ft./sec.
  - Pipe bends shall have a minimum radius of 2 x pipe diameter.
  - Pick up points shall be designed in accordance with the standards set forth in "Industrial Ventilation" published by American Conference of Governmental Industrial Hygienists.
- Fans shall be designed so that noise levels are less than or equal to 85db at a distance of 3ft.

2. **Installation:**

- All particulate matter control device and fan installations shall provide adequate access for personnel and any maintenance activities that might be needed.
- Clean air shall be provided for bag the cleaning system.

3. **Operation:**

- All operation shall be followed according to manufactures guidelines and specifications, located in maintenance files. At no time shall a dust collector be modified without proper engineering and required air permitting.

Monitoring – Particulate Matter Control Devices

1. **Process Particulate Matter Control Devices:**

- Static pressure across the particulate matter control device shall be monitored by the use of a differential pressure transmitter gauge and fan amperes. The differential pressure transmitter will have an output signal to the control room as well as a dial for readings taken at the dust collector. If a control room operator gets an alarm of a high or low differential pressure reading or a variation in fan amperes he will notify the shift foreman. The shift foreman will investigate the nature of the problem and corrective actions will be taken as follows:
    - If the foreman detects visible emissions he will initiate an excursion work order and call a particulate matter control device repairman to fix the problem. The repairman will follow the guide lines in the "Trouble Shooting Section" to make the needed repairs.
    - If no visible emissions are detected he will initiate an excursion work order and call an instrument repairman to check the instruments.
    - The foreman will log all incidents in his shift log.
- All incidents requiring instrument or particulate matter control device maintenance personnel will be logged into the computerized MP2 maintenance system as an excursion work order, identified by the particulate matter control device nomenclature.
- After any repairs are done due to visible emissions, a visual emissions check will be made to ensure the particulate matter control device is operating properly before it is released to production personnel.

2. **Utility Particulate Matter Control Devices:**

- It is the responsibility of all Phoenix Cement Company employees to report any visible emissions from any particulate matter control device when observed. Utility dust collectors are checked weekly by particulate matter control device repairmen and the results of their inspections are recorded in their maintenance logs. If visible emissions are reported by an employee or particulate matter control device repairman the following actions are taken:

- The shift or dust particulate matter control device foreman is notified. In the event a shift foreman is notified he will follow the procedures for process particulate matter control devices. If the dust particulate matter control device foreman is notified he will instruct the needed personnel to repair the problem.
- After repairs have been made according to the particulate matter control device foreman's instructions, repairs will be logged into the computerized MP2 maintenance system. Before releasing the particulate matter control device to production personnel a visual emissions check will be made to ensure the proper operation of the particulate matter control device.

Inspection and Maintenance

1. **Scheduled Inspections:**

- All particulate matter control devices will have a weekly inspection by a particulate matter control device repairman. The inspections will be setup in the computerized MP2 maintenance system and all inspection reports will be logged onto the system. The following items will be inspected:
  - Inspect for visible emissions.
  - Check differential pressure to be sure it is in the normal range for that particular dust collector.
  - Inspect blow pipe valves for malfunction.
  - Determine whether water trap on air header are properly draining.
  - Inspect fan for vibration, hot bearings, loose belts, and air leaks.
  - Inspect ductwork for holes.
  - Check damper linkage and proper damper setting (if equipped).
  - Check for proper operation of the tipping valves or rotary air lock at the dust hopper outlet.
  - Inspect dust hopper for plugging.
  - Inspect the screw or aeroslide under the tipping valves or rotary feeder for malfunctions.
  - Inspect dust collector inlet pipes for plugging.
  - Check air connections and instrumentation connections.
  - Inspect manometer for fluid (if equipped).
  - Inspect particulate matter control device housing for cracks and holes.
  - Inspect timer operation.

- Inspect timer to determine whether it is operating according with specifications located in maintenance files.

2. **Repairman Duties and Responsibilities:**

- The primary responsibility of the repairman are to:
  - Install and maintain various types of particulate matter control devices.
  - Maintain internal and external equipment associated with dust collection.
  - Maintain airlines, airline oilers, and cylinders.
  - Make repairs to particulate matter control device equipment.
  - Trouble shoot any particulate matter control device problem and determine what repairs will be needed.
  - Make inspection reports for particulate matter control devices.
  - Check for visible emissions and record differential pressure in inspection report.
  - Immediately notify particulate matter control device foreman of any operational problems associated with the particulate matter control device.
  - Be available on off hours if needed for urgent repair work.

Particulate Matter Control Device Startup and Shutdown

1. **General Conditions:**

- When new bags are installed, the particulate matter control device must be brought on-line slowly to avoid permanent damage to the filtration media. Without protective dust cake, clean filters are sensitive to dust abrasion and penetration of fine particles. Dust penetration can lead to permanently reduced permeability. The velocity should always be kept low until a sufficient dust cake is built on the bags. This will be indicated by a pressure differential of 1-2 inches water column. The gas flow can then be slowly increased to the design rate.

2. **Startup:**

- Ensure all particulate matter control device components are in good working order and are in proper operating mode.
- Avoid passing below the dew point when dirty gases are present. The air in the system should be above the dew point before the introduction of feed into the system.
- Check monitoring devices for proper operation and calibration.

3. **Shutdown:**

- Remove the feed into the system before allowing the temperature to descend below the dew point. As the collector cools, moisture may condense on the bags once dew point is reached. The inlet and outlet temperatures should be consistent and below the dew point.
- Do not store dust in the hopper. The presence of any moisture can cause it to harden, making it very difficult to remove.
- Allow bags to clean down after dust has stopped entering the hopper and remove this material from the hopper, but do not over clean the filters.
- Check to see that all components are in the proper shutdown mode.

General Operation and Troubleshooting

1. Particulate Matter Control Device Fans:

- As ventilation system changes are needed to accommodate increased production, ventilation needs, or process changes, more airflow is required. If a system has not changed, but airflows are not at the designed level, troubleshooting the fan may return the system to the designed performance level. Follow these steps for checking fan performance:
  - **Check the mechanical condition of the fan.**

    Inspect the fan drive belts for loose or out of alignment conditions. This condition could account for as much as a 20% decrease in fan speed. Check the alignment of the inlet cone and fan wheel. Set to manufactures designed settings for maximum fan performance.
  - **Keep the fan clean.**

    If dust buildup is detected on the fan wheel it must be cleaned to return the fan to it's peak designed capacity.
  - **Check for correct rotation.**

    If repairs are done to the fan motor, rotation must be correct for the fan to move the designed airflow. Fan rotation must also be checked on startup of any new fan installation.
  - **Check dampers and controls.**

    Look for stiff operating dampers or looseness in the control linkage.
- At no time shall a fan be operated beyond its designed speed. If more airflow is required for the system, engineering will be consulted as to any desired changes to the fan or particulate matter control device. Prior to any changes to the fan or particulate matter

control device, air operating permits will be checked and a determination will be made as to the need for permit modifications.

2. **Differential Pressures:**

- Differential pressure across a dust collector is of major concern when operating a system. High differential pressure can cause damage to the filters or be an indication of decreased airflow through the system. Low differential pressure can cause fabric bleedthrough and blinding if the dust cake is too light.
- The location of differential pressure taps is critical to proper pressure monitoring. Pressure taps will be located directly above and below the tubesheet to eliminate mechanical losses in the gauge readings. One of the following pressure gauges will be used; manometer, Magnahelic, or differential pressure transmitter. A sudden drop in pressure will indicate a leak in the system. A sharp rise in pressure will indicate the filters are blinded or "caked" with particulate.
- For a particulate matter control device to operate efficiently, the fabric filters must capture and release particulate during the cleaning cycle. The effectiveness of this process depends on the development of an initial control layer of dust that protects the fabric interstices.

3. **Pulse-Jet Types:**

- In pulse-jet particulate matter control devices, the cleaning function not only removes the collected dust, it rearranges the remaining dust cake structure on the bag, resulting in a change in differential pressure. In a unit with high upward gas velocities, mechanical separation of the fine submicron dust can occur, creating a dust cake structure that is very dense. A dense dust cake creates a greater resistance to airflow and higher differential pressures.
- **Pulse Cycle.**

  The cleaning cycle for standard high pressure, low volume pulse-jet collectors should be adjusted so the pulse duration produces a short, crisp pulse that creates an effective shock wave in the bag. This duration is generally set to fire for 0.10 to 0.15 second, based on the manufactures recommendations. (Other styles, such as low pressure, high volume pulsing and medium pressure, medium volume, use different settings to operate and should be examined on an individual basis.)

  The frequency of the pulse cleaning is also vital to proper dust cake retention. This frequency can vary from 1 to 30 seconds or more and is adjusted by means of a setting on the timer board or PLC.

  To ensure proper cleaning frequency, an automatic "clean-on-demand" system utilizing a pressure switch such as a differential pressure transmitter can be installed. This type of system automatically steps through a cleaning cycle that starts when the high differential pressure set point is reached and stops when it cleans down to the low differential pressure set point. It can also save on compressed air usage. The range on the high/low differential setting should be 0.5-1.0 inches maximum.

On pulse-jet types, the pulse frequency can be increased. However, the next pulse should not be programmed to fire until the compressed air pressure is regained so the same pulse force is obtained for each row cleaned. The regain of air pressure is dependent on the capability of the compressed air system tied to the dust collector and the size of the compressed air piping run to the header tank. The pipe should be large enough to repressurize the header in a minimum time. Typically, the feed line should be a 1 inch diameter pipe, depending on compressed air used.

- **Troubleshooting Pulse-Jet Cleaning.**

Pulse-valve malfunctions are usually caused by diaphragm failure or dirt, oil, and / or moisture getting into the valve body. These problems can be identified by disassembling the valve and inspecting it. Before checking valves, verify that the tubing and fittings between diaphragm (pulse) valves and solenoid valves are not leaking, and that the tubing is connected to the inlet port on the solenoid valve.

Prior to servicing the diaphragm valve, the timer board, and the solenoid pilot valve needs to be checked for proper operation. If it is malfunctioning, refer to the troubleshooting flow chart at the end of this section.

- **Cage Inspections.**

Cages are to be inspected any time a new bag is installed. The most common problems are bent and damaged cages that cannot properly support the filter bag. Cages in corrosive environments can eventually rust and pit.

Corroded areas begin to abrade the fabric as it flexes during the cleaning cycle. Cage bottom pans with sharp edges can cause similar damage.

- **Bag to Cage Fit.**

For proper performance of pulse-jet filters, the fit relationship between the bag and cage is critical. Filters that are too loose or too tight will severely limit collection efficiency and lead to premature physical failure.

- **Pulse-Jet Bag Installation.**

Correct filter bag installation is important to maximize the life of the fabric. Bags with flanges or cuffs that fold over the tops of their support cages should be checked for smoothness around the edge to prevent leakage and bag abrasion. Seam placement on bottom load bags should be 180 degrees from the split or gap in the cage collar. The clamp on these bags should be installed 90 degrees in relation to the seam on the bag and positioned on the groove in the cage. Snapband bags for top access pulse-jet units should be installed with the seams all facing the same direction. This allows for identification of areas where problems are occurring and improved troubleshooting of the unit.

4. **Reverse Air Types:**

- To get the maximum performance in reverse air systems, it is necessary to monitor the manometer or Magnehelic gauge on each compartment during the cleaning cycle. A reading should be taken at each of the following times:
  - Before the module starts to clean.
  - When the module is isolated before the reverse air damper opens.
  - When the reverse air is energized.
  - During the null period after the reverse air.
  - When the module is returned to service.

  When the module is isolated, any reading other than zero on the manometer is an indication that the isolation damper is not sealing. Air moving through the module due to leakage can affect the ability of the reverse air to provide maximum cleaning efficiency. Also, improper tensioning of the filter bag can cause ineffective bag movement resulting in poor cleaning and bag abrasion.

  It is also very important that the "null period" of collection after cleaning be of sufficient time to allow for the fine particles to fall the length of the bag and be collected in the hopper. (This is also true for shaker collection.)

- **Compartmental Valves and Dampers:**

  Off-line compartmental cleaning requires isolation from the rest of the collector to get effective dust removal from the filter bag. Regardless of the type of damper or valve used to achieve this, certain conditions can be checked to ensure proper isolation. The seat of the valve is primary to a good seal.

  Another common problem is material buildup in the plenum around the valve that could prevent the valve or damper from sealing properly, particularly if moisture is present in the gas stream. Corrosion on the valve seat can also prevent a good seal.

  Consideration of valve and damper maintenance requirements during the initial design phase or when making changes to a system will help ensure trouble-free and effective operation of these assemblies. Components that are replaced in difficult access areas may not receive necessary maintenance.

5. **Air Inleakage:**

- Small air leaks will starve a dust collector system. In a ventilation system, the fan is sized to overcome all of the design static resistance in the system. The suction pull is greater at leaks located closer to the fan, and the volume of inleakage increases. To calculate the volume of inleakage, use the following formula:

  $$CFM = 4{,}005 \sqrt{VP} \times Area\ (ft.^2)$$

  VP = velocity pressure in inches w.c.

CFM = airflow in $ft.^3$/min.

- Leakage in a positive pressure system located after the fan outlet will cause dust emissions and housekeeping problems.
- On the negative pressure side of the fan, inleakage causes air volume problems by reducing suction at the pickup points. While not as large a problem as with hot gas, corrosion can still form around leaks due to moisture from ambient air being drawn into the system.
- Opportunities for inleakage exist through the ventilation system. Common trouble spots are expansion joints, access doors, screw conveyor covers, rotary air locks, poorly connected seams, existing corrosion spots, or cracked welds.

6. **Ambient Air Leaks In Hot Gases:**

- The fan is a mechanical pump that moves a set volume of air. The air capacity of the fan is determined by the pressure resistance of the system. The fan is a fixed volume machine since it typically runs at a fixed speed. Temperature changes also cause load changes to the fan drive.
- Inleakage of ambient air satisfies the volumetric needs of the fan reducing the process hot air because of its greater air density. The density of ambient air is almost 1.5 times heavier than process air at 325^0F.
- Inleakage can also lower the operating temperature below the dew point, causing condensation with the following results:
    - Increased maintenance and replacement expenses due to component corrosion and deterioration.
    - Shortened filter bag life caused by surface agglomeration and chemical attack.
    - Higher static pressure losses across the filters.
    - Lower gas flow because of a denser dust cake.

7. **Sequencing Compartment Cleaning:**

- In systems where dust is delivered to a screw conveyor, the amount of dust removed can be dependent on the sequencing of the modules above the screw.
- Improper sequencing of the cleaning system on a compartmental dust collector with pyramid hoppers can cause overloading of the discharge screw conveyor and poor dust removal. This can cause overfilling of hoppers, and in turn, bag wear, higher pressure drop, and reduced gas flow.
- When a compartment cleans, the material often has substantial volume and fills the lower portion of the hopper. This volume immediately fills the screw conveyor. As subsequent hoppers clean, it may be impossible for the new material to be discharged until the material from the previously cleaned compartment is fully removed from the

screw conveyor. The compartment cleaning should be sequential in a manner that is concurrent with the screw conveyor flow. Begin cleaning with the compartment furthest from the discharge and finish with the compartment closest to the discharge area. In addition, the air locks and screw conveyor must be adequately sized to handle the maximum dust load the collector may experience.

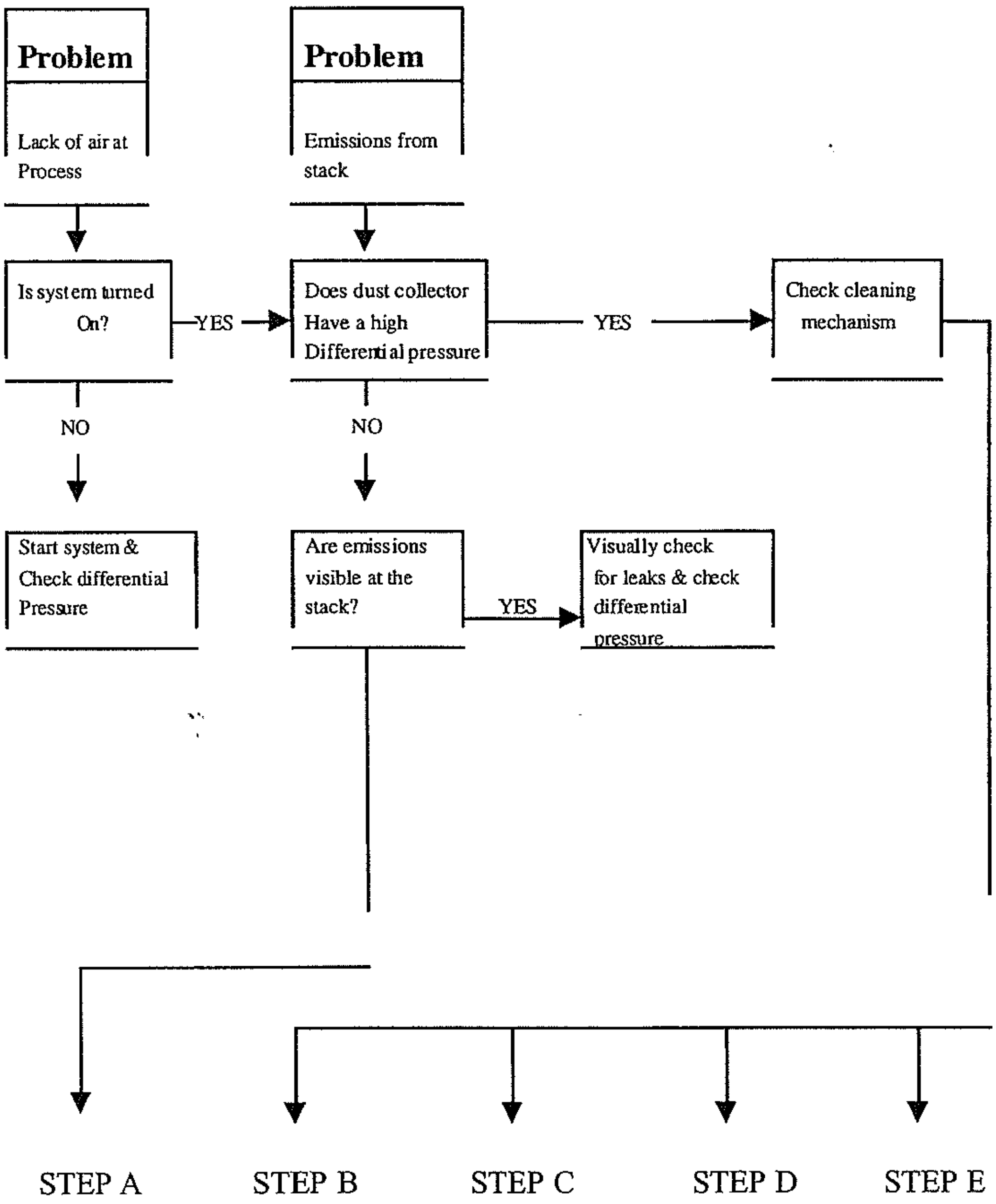
Bag and Cage Damage evaluation

Damage	Cause	Solution	Options
Bags have internal abrasion marks along vertical wires.	1. Cage wires are deeply pitted as a result of excessive corrosion. 2. Bag is oversized.	1. Replace with new galvanized steel cage. 2. Replace with new bag that is the correct size.	1a. Use a mild steel cage if chloride and moisture (HCL) are present. 1b. Use an epoxy coated cage.
Cuts and/or internal damage is noticeable at the bottom of the bag where it contacts with the edge of pan.	Sharp edge on pan.	Use cage with rounded edge pan.	Increase the number of vertical wires to reduce amount of fabric drawn between wires across edge of pan.
Cage body has collapsed; broken welds and bent wires have caused bag wear points.	1. Cage has been weakened by corrosion. 2. Pressure exceeds cage strength. 3. Rough handling by maintenance crews.	1. Replace with standard cage. 2. Change operating conditions to reduce differential pressure.	1. Replace with a coated cage or a stainless cage. 2a. Increase the number of cage rings. 2b. Make cage from heavier gauge wire.
Bag failure resulting from excess fabric slack pinch above top ring or below bottom ring.	Cage is tapered or bowed between the ring and the pan.	Design cage with minimal taper (larger pan or top).	Change ring spacing to minimize taper or bowing.
Flex line failures between the vertical wires.	Bags are not adequately supported by cages.	Replace with cage providing more support (20 vertical wires and/or closer horizontal ring spacing).	1. Convert from 10 or 12 wire cage to 20 wire cage design. 2. Reduce ring spacing.
Bags are difficult to remove from bags.	Corrosion causes rough surfaces which increase friction between the bag and the cage. (Actual chemical bonding between the cage wire and fabric can occur.)	Replace all cages with new standard cage.	1. Use coated or stainless steel cages. 2. Convert to omni top cages to allow for removal of snapband bags and cages as an assembly.

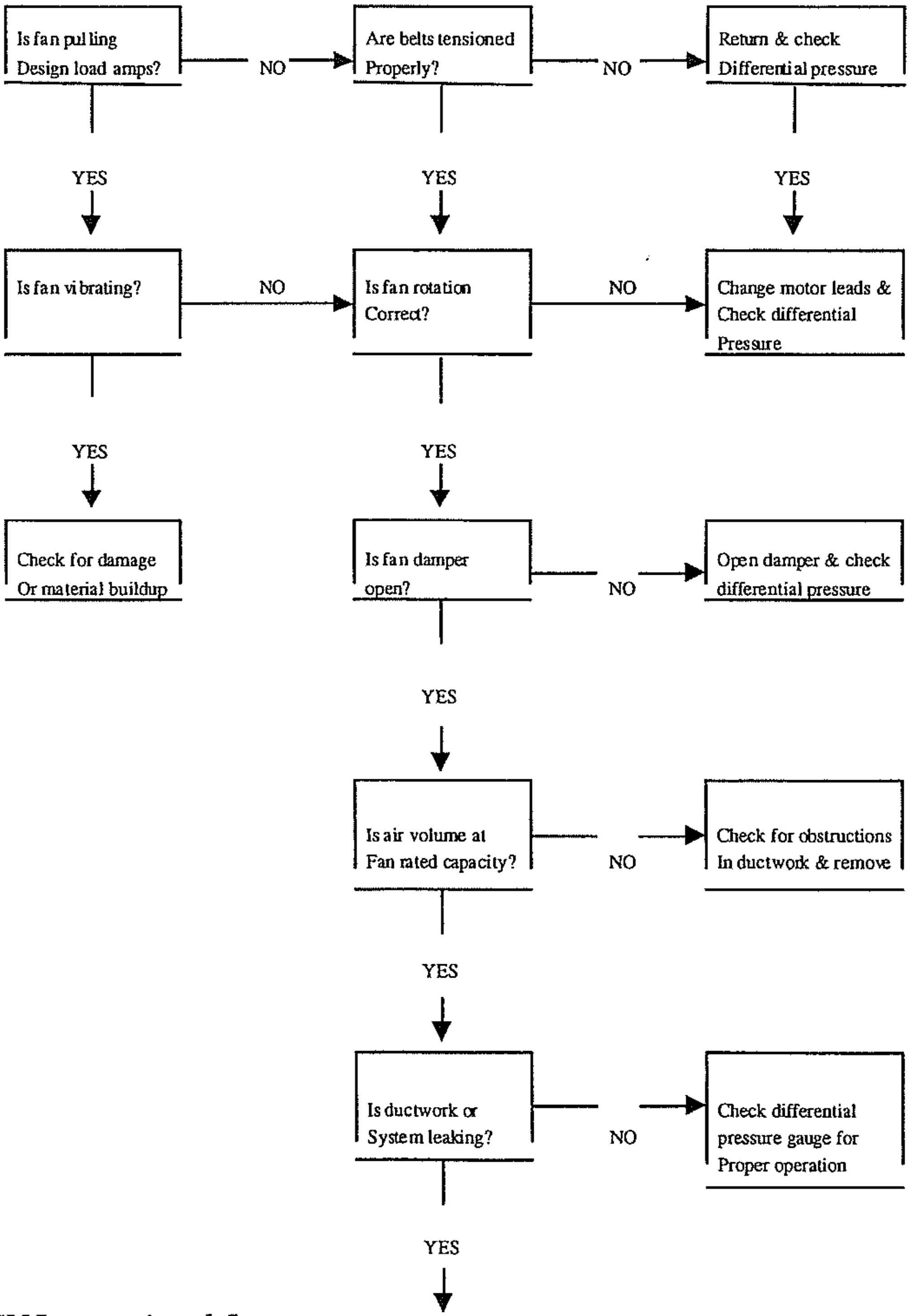
SECTION 3.0

CORRECTIVE ACTION PROCEDURES

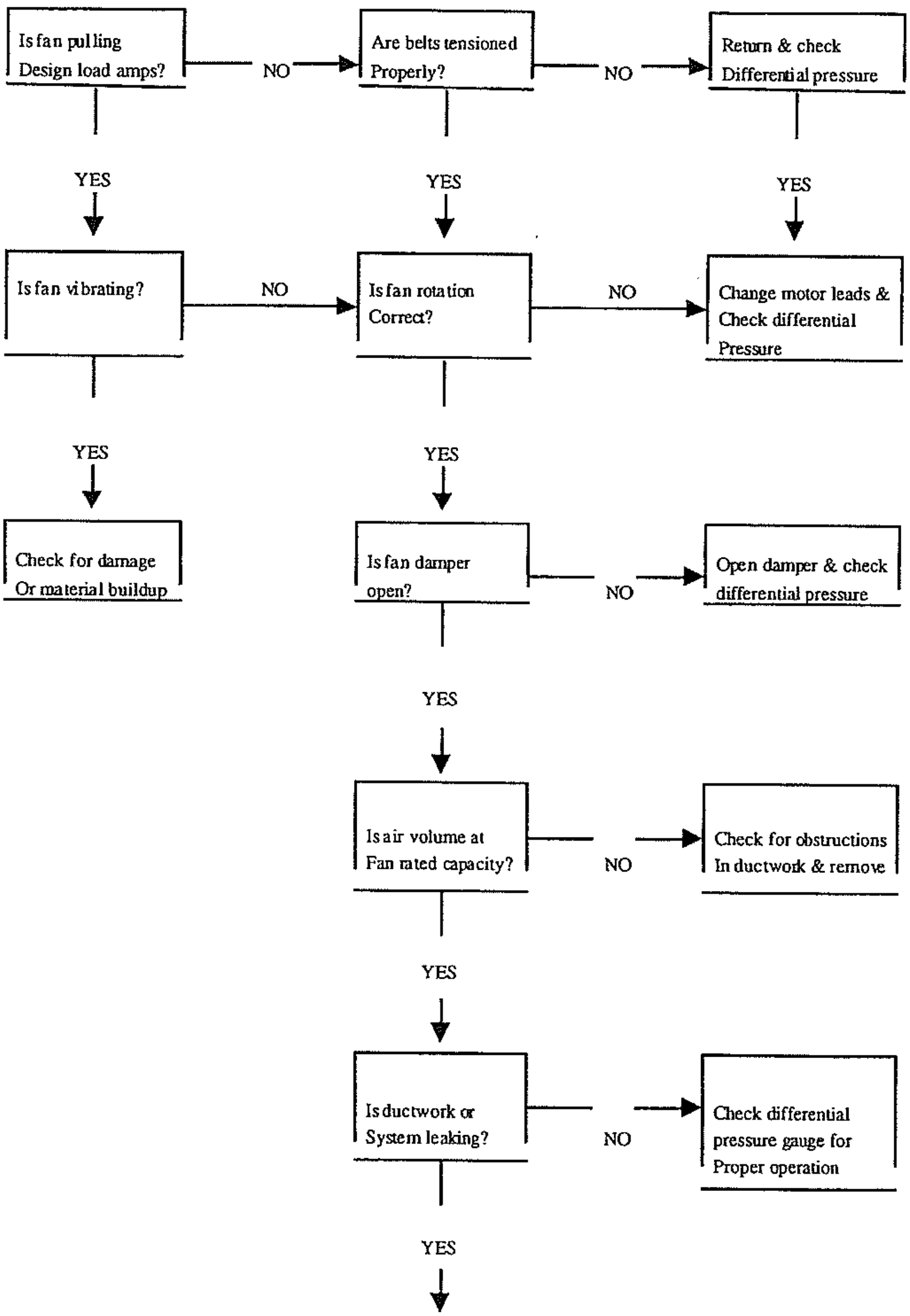
Troubleshooting Chart



STEP A


Is fan pulling Design load amps?
NO
Are belts tensioned Properly?
NO
Return & check Differential pressure
YES
YES
YES
Is fan vibrating?
NO
Is fan rotation Correct?
NO
Change motor leads & Check differential Pressure
YES
YES
Check for damage Or material buildup
Is fan damper open?
NO
Open damper & check differential pressure
YES
Is air volume at Fan rated capacity?
NO
Check for obstructions In ductwork & remove
YES
Is ductwork or System leaking?
NO
Check differential pressure gauge for Proper operation
YES

STEP A



Is fan pulling Design load amps?
NO
Are belts tensioned Properly?
NO
Return & check Differential pressure
YES
YES
YES
Is fan vibrating?
NO
Is fan rotation Correct?
NO
Change motor leads & Check differential Pressure
YES
YES
Check for damage Or material buildup
Is fan damper open?
NO
Open damper & check differential pressure
YES
Is air volume at Fan rated capacity?
NO
Check for obstructions In ductwork & remove
YES
Is ductwork or System leaking?
NO
Check differential pressure gauge for Proper operation
YES

STEP B

Is there power in & out of timer?
- NO → Turn on power &/or repair timer
- YES ↓

Is manifold Pressure at Manufacturer's Recommended Setting?
- NO → Check for leaking solenoids & pulse valves; check compressed air source and check differential pressure
- YES ↓

Do solenoids & Diaphragms Operate properly?
- NO → Repair solenoid or diaphragm & check Differential Pressure
- YES ↓

Is pulse duration At recommended Setting? (0.1-.015 sec.)
- NO → Change setting & check differential Pressure
- YES ↓

Is cleaning Interval at the Lowest setting That will allow Air manifold Pressure to Build?
- NO → Change setting & check differential pressure

STEP C

Is there power in & out of timer?
- NO → Turn on power &/or repair timer
- YES ↓

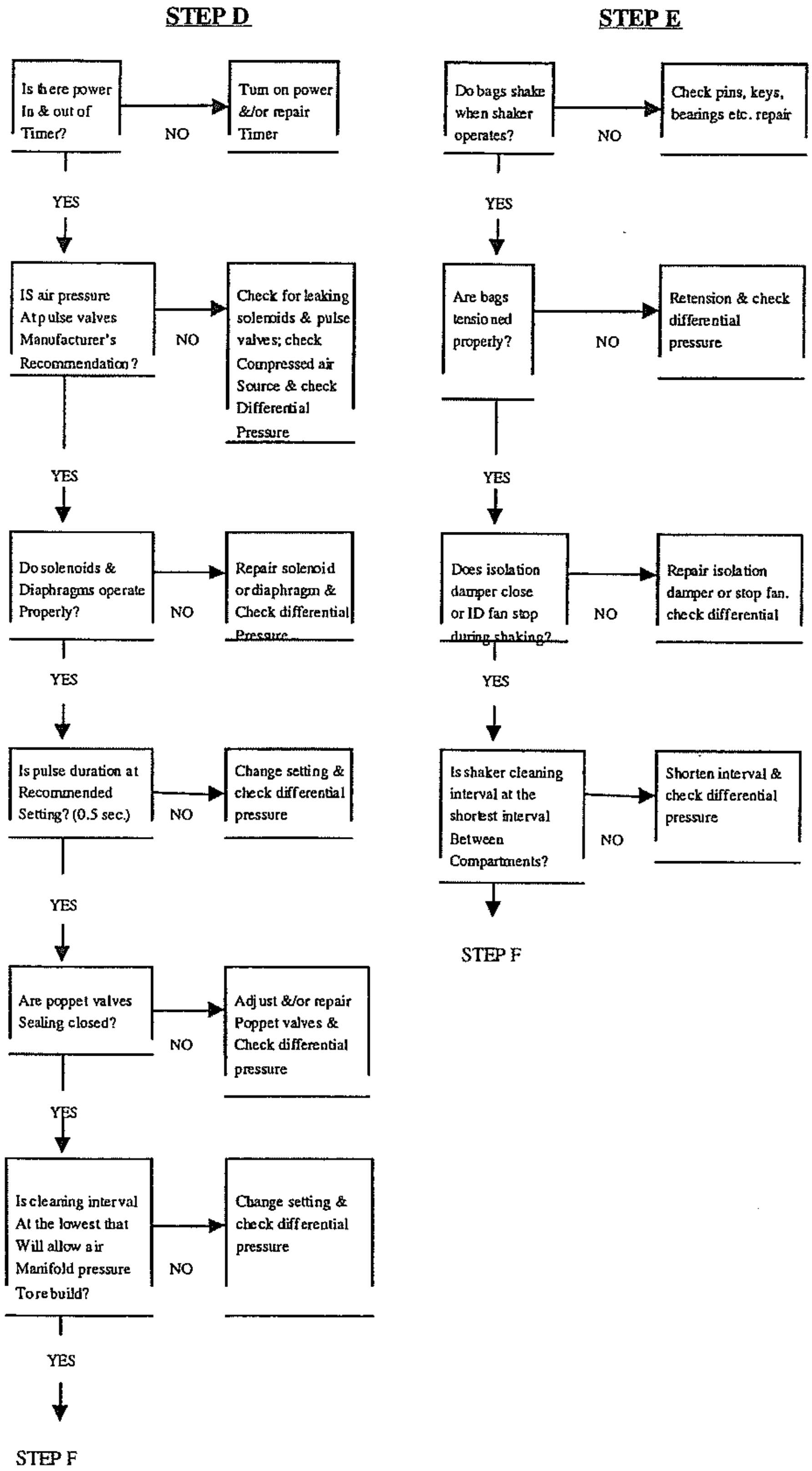
Are isolation dampers sealing properly?
- NO → Adjust &/or repair & check differential pressure
- YES ↓

Is reverse air fan running?
- NO → Turn on & check differential pressure
- YES ↓

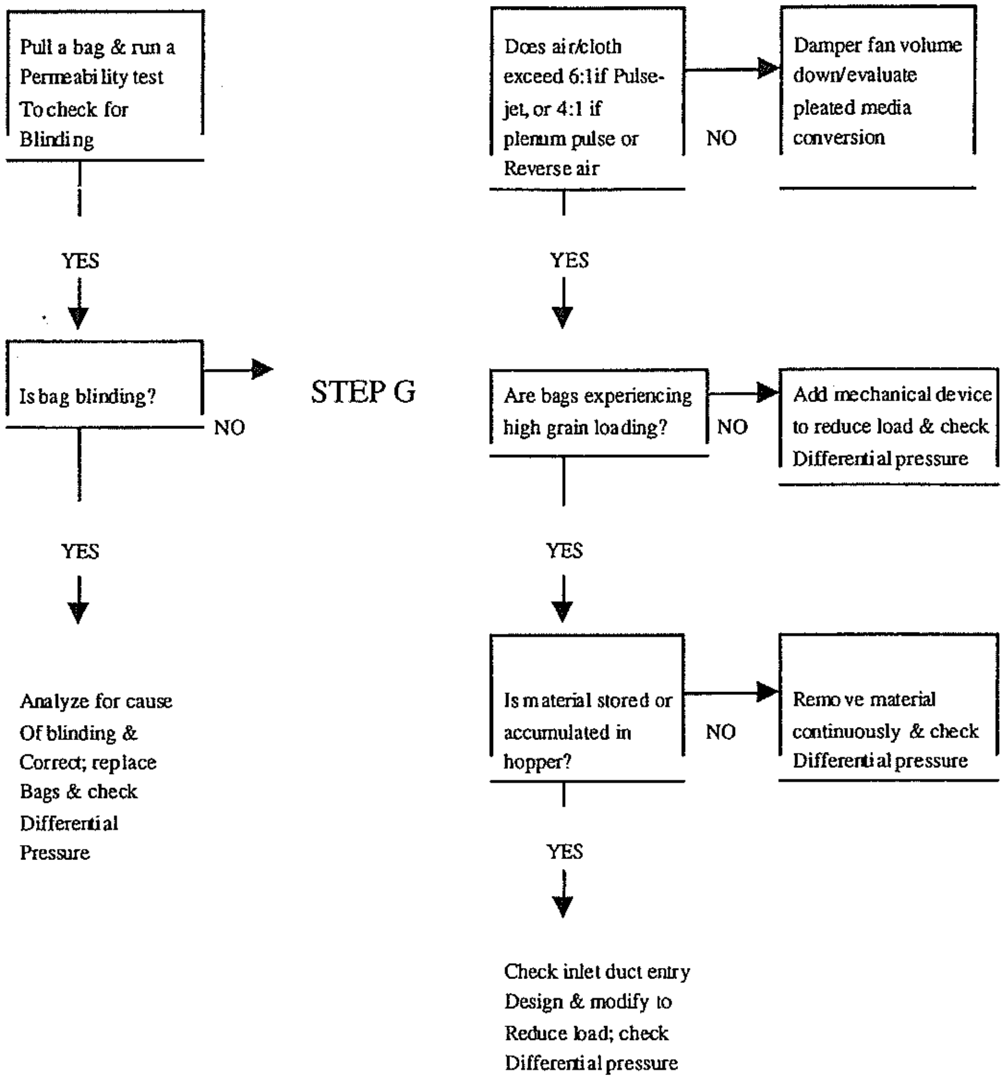
Is reverse air fan rotation correct?
- NO → Change motor Leads & check differential pressure
- YES ↓

Is cleaning cycle for reverse air dwell set at manufacturer's specifications?
- NO → Change setting & check differential pressure

[redacted]


STEP D
Is there power In & out of Timer?
NO
Turn on power &/or repair Timer
YES
IS air pressure At pulse valves Manufacturer's Recommendation?
NO
Check for leaking solenoids & pulse valves; check Compressed air Source & check Differential Pressure
YES
Do solenoids & Diaphragms operate Properly?
NO
Repair solenoid or diaphragm & Check differential Pressure
YES
Is pulse duration at Recommended Setting? (0.5 sec.)
NO
Change setting & check differential pressure
YES
Are poppet valves Sealing closed?
NO
Adjust &/or repair Poppet valves & Check differential pressure
YES
Is cleaning interval At the lowest that Will allow air Manifold pressure To rebuild?
NO
Change setting & check differential pressure
YES
STEP F
STEP E
Do bags shake when shaker operates?
NO
Check pins, keys, bearings etc. repair
YES
Are bags tensioned properly?
NO
Retension & check differential pressure
YES
Does isolation damper close or ID fan stop during shaking?
NO
Repair isolation damper or stop fan. check differential
YES
Is shaker cleaning interval at the shortest interval Between Compartments?
NO
Shorten interval & check differential pressure
STEP F

STEP F **STEP G**



Pull a bag & run a Permeability test To check for Blinding
YES
Is bag blinding?
NO
STEP G
YES
Analyze for cause Of blinding & Correct; replace Bags & check Differential Pressure
Does air/cloth exceed 6:1 if Pulse-jet, or 4:1 if plenum pulse or Reverse air
NO
Damper fan volume down/evaluate pleated media conversion
YES
Are bags experiencing high grain loading?
NO
Add mechanical device to reduce load & check Differential pressure
YES
Is material stored or accumulated in hopper?
NO
Remove material continuously & check Differential pressure
YES
Check inlet duct entry Design & modify to Reduce load; check Differential pressure

Formulas

ACFM	Actual cubic feet per minute	**PSI**	Pounds per square inch
AMP	Amperage	**RPM**	Revolutions per minute
Dia	diameter	**SP**	Static pressure
FPM	Feet per minute	**SPWG**	Static pressure water gauge
L	length	**VP**	Velocity pressure, inches of water

Total CFM = Velocity (FPM) x Duct Area (ft.^{2})

Velocity = 4,005 $\sqrt{}$VP at standard Conditions (70^0 F at sea Level)

Velocity at Elevated Temperatures and sea Level, Using Standard Pitot Tube:

Velocity, FPM = 174 $\sqrt{}$(VP x Air Stream Temperature ^{0}F + 460

Total Cloth Area, ft.^{2}= [(Bag Dia (in.) x 3.14 x Bag L (in.)) ÷ 144] x Total Number of Bags

Gross Air-to Cloth Ratio = ACFM ÷ Total Cloth Area (ft.^{2})

Net Air-to Cloth Ratio = ACFM ÷ Total On-Line Cloth Area (ft.^{2})

1 in. SPWG = .578 oz./in.^{2} = .0361 PSI = .0735 in. Hg (Mercury)

1 PSI Air Pressure = 27.70 in. SPWG = 2.036 in. Hg = 0.068 Bar = 0.0703 kg./cm^2

Can Velocity = ACFM ÷ [Total Tube Sheet Area (ft.^{2}) – (Hole Area, (ft.^{2}) x Number of Holes]

7,000 Grains = 1 lb. = 16 oz. = 453.6 grams   **1 lb./ft.^{3}** = 0.0624 kg./m^3

Grain Loading Expressed in Grains/ft.^{3} = (Lbs. Of Dust Handled per Minute x 7,000) ÷ ACFM

Lbs. Of Dust/Minute = (Grains/ft.^{3} x ACFM) x 7,000

1 Horsepower = 1.34 kilowatts

1 inch = 25.4 mm = 0.0254 meter

^{0}**C** = (^{0}F – 32) x (5/9) ^{0}**F** = [^{0}C x (9/5)] + 32

(530^0 F)

SCFM = ACFM x Actual Temperature (^{0}F) + 460^0 F

Acknowledgements

Phoenix Cement Company wishes to thank BHA of 8800 East 63rd Street, Kansas City, Missouri for the information presented in this document. BHA has been a leader in helping the cement industry achieve environmentally compliant plants.

SECTION 4.0

INSPECTION PROCEDURES –

COMBUSTION SYSTEM COMPONENTS

SECTION 4.1

KILN BURNER INSPECTION AND MAINTENANCE

5. MAINTENANCE

5.1 Preventive maintenance, survey

- **.1 Lubrication**
- **.2 Cleaning**
- **.3 Inspection and adjustment**
- **.4 Checking of condition**
- **.5 Replacement (incl. lubricants)**
- **.6 Performance test**

Pos.	Text	.1	.2	.3	.4	.5	.6
00	Burner installation		4A		A		A
03	Burner			A			
05,44	Expansion joints				A		
20	Burner pipe		D		M	T	
25	Coal inlet				A	T	
33	Central duct				A	T	
40	Conical air nozzle				A	T	

D = per 8-hour operation
S = weekly
M = monthly
A = yearly
T = see text in instruction manual

A number in front of the letter indicates the frequency of procedure. For example, 2M = twice a month.

5.1.2 Clean-up

Burner installation (00). General cleaning on and around the equipment.

Burner pipe (20). Remove deposits from the burner pipe.

5.1.3 Inspection and adjustment

Burner (03). When the kiln is shut down, check that the burner is correctly positioned in the kiln.

5.1.4 Checking of condition

Burner installation (00). Check that all hoses and expansion joints are intact. Check the tightness of the closing plate at the door.

Burner pipe (20). Make a visual check to determine if the ceramic coating has sustained damage.

Coal inlet (25) and central duct (33). Check the Densit lining for wear.

Conical air nozzle (40). In connection with reconditioning of the burner pipe, check the condition of the castable around the conical air nozzle. Also check whether the nozzle is affected by corrosion and/or cracks.

5.1.5 Replacement

Burner pipe (20). If the visual inspection reveals damage involving a partial exposure of the steel surface, the burner pipe must be replaced immediately. The pipe must always be replaced in connection with the annual shutdown for maintenance. A complete spare burner pipe unit consisting of burner pipe with swirler unit and air nozzle, inclusive of lining, must always be held available at the plant.

For replacement of burner pipe, see sub-sections 3.5 and 3.7.

Coal inlet (25) and central duct (33). Densit lining to be replaced when deemed necessary.

Conical air nozzle (40). In connection with the reconditioning of burner pipe, the nozzle unit must be replaced if damaged. A spare unit should always be held available. The spare unit is available in excess length in order to avoid coinciding welds.

5.1.6 Performance test

Burner installation (00). Move all adjustment devices to eliminate the risk of their movement being restricted at any location.

5.2 Faults and remedial action

5.2.1 Trouble-shooting chart

Observation	Potential fault	Remedy Pos. 5.2.2
Large, smooth flame extending across the entire cross-sectional area of kiln	Momentum of primary air too low	1
Hard, very bright flame	Momentum of primary air too high	2
Very short flame plume, resulting in overheated burner tip	Momentum of primary air too high	2
	Swirling of primary air too high	3
Unstable flame with long plume	Defective oil nozzle	4
	Momentum of primary air too low	1
Skew flame	Defective oil nozzle	4
	Clogging of coal duct	5
	Dust deposits on burner pipe	6

5.2.2 Remedial action

Pos.	Fault	Possible cause	Remedy
1	Momentum too low	Incorrect adustment	Adjust, see sub-section 4.1
		Defective burner pipe	Install replacement unit
		Incorrect connection of primary air	Install replacement unit
		Malfunction of fan	See instruction manual
2	Momentum too high	Incorrect adjustment	Adjust, see sub-section 4.1
3	Excessive swirl	Incorrect adjustment	Adjust damper (33)
4	Oil nozzle defective	Malfunction of oil burner set	See instruction manual
5	Clogging of coal duct	Penetration of coal dust into coal duct	Retract burner and clean it
6	Deposits on burner pipe	Excessive swirl or momentum	Remove deposits regularly. If necessary, reduce swirl or momentum.

SECTION 4.2

PREHEATER INSPECTION AND MAINTENANCE

5. MAINTENANCE

5.1

Preventive maintenance, survey

.1 Lubrication

.2 Cleaning

.3 Inspection and adjustment

.4 Checking of condition

.5 Replacement (incl. lubricants)

.6 Performance test

Pos.	Text	.1	.2	.3	.4	.5	.6
02	Pipe system	.	2A	.	A	.	.
03	Burner asssembly	.	2A	.	A	.	.

D = per 8-hour operation
S = weekly
M = monthly
A = yearly
T = see text in instruction manual

A number in front of the letter indicates frequency of procedure. For instance 2M = twice a month.

5.2

Clean-up

Pipe system (02) and burner assembly (03)

Clean the parts and their surroundings. Always ensure that dust deposits, if any, are removed from the radiation shields.

5.4

Condition checking

Pipe system (02) and burner assembly (03)

Check that the pipe connections are tight.

Check tightness of quick-acting copulings (11).

Check the condition of the packing; replace as required.

Check tightness and condition of steel hoses.

Check for bakings in the gas nozzle holes.

SECTION 5.0

EPA METHOD 22

AND

EPA METHOD 9

METHOD 22 - VISUAL DETERMINATION OF FUGITIVE EMISSIONS FROM MATERIAL SOURCES AND SMOKE EMISSIONS FROM FLARES

NOTE: This method is not inclusive with respect to observer certification. Some material is incorporated by reference from Method 9.

1.0 Scope and Application.

This method is applicable for the determination of the frequency of fugitive emissions from stationary sources, only as specified in an applicable subpart of the regulations. This method also is applicable for the determination of the frequency of visible smoke emissions from flares.

2.0 Summary of Method.

2.1 Fugitive emissions produced during material processing, handling, and transfer operations or smoke emissions from flares are visually determined by an observer without the aid of instruments.

2.2 This method is used also to determine visible smoke emissions from flares used for combustion of waste process materials.

2.3 This method determines the amount of time that visible emissions occur during the observation period (*i.e.*, the accumulated emission time.) This method does not require that the opacity of emissions be determined. Since this procedure requires only the determination of whether visible emissions occur and does not require the determination of opacity levels, observer certification according to the procedures of Method 9 is not required. However, it is necessary that the observer is knowledgeable with respect to the general procedures for determining the presence of visible emissions. At a minimum, the observer must be trained and knowledgeable regarding the effects of background contrast, ambient lighting, observer position relative to lighting, wind, and the presence of uncombined water (condensing water vapor) on the visibility of emissions. This training is to be obtained from written materials found in References 1 and 2 or from the lecture portion of the Method 9 certification course.

3.0 Definitions.

3.1 *Emission frequency* means the percentage of time that emissions are visible during the observation period.

3.2 *Emission time* means the accumulated amount of time that emissions are visible during the observation period.

3.3 *Fugitive emissions* means emissions generated by an affected facility which is not collected by a capture system and is released to the atmosphere. This includes emissions that (1) escape capture by process equipment exhaust hoods; (2) are emitted during material transfer; (3) are emitted from buildings housing material processing or handling equipment; or (4) are emitted directly from process equipment.

3.4 *Observation period* means the accumulated time period during which observations are conducted, not to be less than the period specified in the applicable regulation.

3.5 *Smoke emissions* means a pollutant generated by combustion in a flare and occurring immediately downstream of the flame. Smoke occurring within the flame, but not downstream of the flame, is not considered a smoke emission.

4.0 Interferences.

4.1 Occasionally, fugitive emissions from sources other than the affected facility (*e.g.*, road dust) may prevent a clear view of the affected facility. This may particularly be a problem during periods of high wind. If the view of the potential emission points is obscured to such a degree that the observer questions the validity of continuing observations, then the observations shall be terminated, and the observer shall clearly note this fact on the data form.

5.0 Safety.

5.1 Disclaimer. This method may involve hazardous materials, operations, and equipment. This test method may not address all of the safety problems associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to performing this test method.

6.0 Equipment.

6.1 Stopwatches (two). Accumulative type with unit divisions of at least 0.5 seconds.

6.2 Light Meter. Light meter capable of measuring illuminance in the 50 to 200 lux range, required for indoor observations only.

7.0 Reagents and Supplies. [Reserved]

8.0 Sample Collection, Preservation, Storage, and Transfer. [Reserved]

9.0 Quality Control. [Reserved]

10.0 Calibration and Standardization. [Reserved]

11.0 Analytical Procedure.

11.1 Selection of Observation Location. Survey the affected facility, or the building or structure housing the process to be observed, and determine the locations of potential emissions. If the affected facility is located inside a building, determine an observation location that is consistent with the requirements of the applicable regulation (*i.e.*, outside observation of emissions escaping the building/structure or inside observation of emissions directly emitted from the affected facility process unit). Then select a position that enables a clear view of the potential emission point(s) of the affected facility or of the building or structure housing the affected facility, as appropriate for the applicable subpart. A position at least 4.6 m (15 feet), but not more than 400 m (0.25 miles), from the emission source is recommended. For outdoor locations, select a position where the sunlight is not shining directly in the observer's eyes.

11.2 Field Records.

11.2.1 Outdoor Location. Record the following information on the field data sheet (Figure 22-1): Company name, industry, process unit, observer's name, observer's affiliation, and date. Record also the estimated wind speed, wind direction, and sky condition. Sketch the process unit being observed, and note the observer location relative to the source and the sun. Indicate the potential and actual emission points on the sketch.

11.2.2 Indoor Location. Record the following information on the field data sheet (Figure 22-2): Company name, industry, process unit, observer's name, observer's affiliation, and date. Record as appropriate the type, location, and intensity of lighting on the data sheet. Sketch the process unit being observed, and note the observer location relative to the source. Indicate the potential and actual fugitive emission points on the sketch.

11.3 Indoor Lighting Requirements. For indoor locations, use a light meter to measure the level of illumination at a location as close to the emission source(s) as is feasible. An illumination of greater than 100 lux (10 foot candles) is considered necessary for proper application of this method.

11.4 Observations.

11.4.1 Procedure. Record the clock time when observations begin. Use one stopwatch to monitor the duration of the observation period. Start this stopwatch when the observation period begins. If the observation period is divided into two or more segments by process shutdowns or observer rest breaks (see Section 11.4.3), stop the stopwatch when a break begins and restart the stopwatch without resetting it when the break ends. Stop the stopwatch at the end of the observation period. The accumulated time indicated by this stopwatch is the duration of observation period. When the observation period is completed, record the clock time. During the observation period, continuously watch the emission source. Upon observing an emission (condensed water vapor is not considered an emission), start the second accumulative stopwatch; stop the watch when the emission stops. Continue this procedure for the entire observation period. The accumulated elapsed time on this stopwatch is the total time emissions were visible during the observation period (*i.e.*, the emission time.)

11.4.2 Observation Period. Choose an observation period of sufficient length to meet the requirements for determining compliance with the emission standard in the applicable subpart of the regulations. When the length of the observation period is specifically stated in the applicable subpart, it may not be necessary to observe the source for this entire period if the emission time required to indicate noncompliance (based on the specified observation period) is observed in a shorter time period. In other words, if the regulation prohibits emissions for more than 6 minutes in any hour, then observations may (optional) be stopped after an emission time of 6 minutes is exceeded. Similarly, when the regulation is expressed as an emission frequency and the regulation prohibits emissions for greater than 10 percent of the time in any hour, then observations may (optional) be terminated after 6 minutes of emission are observed since 6 minutes is 10 percent of an hour. In any case, the observation period shall not be less than 6 minutes in duration. In some cases, the process operation may be intermittent or cyclic. In such cases, it may be convenient for the observation period to coincide with the length of the process cycle.

11.4.3 Observer Rest Breaks. Do not observe emissions continuously for a period of more than 15 to 20 minutes without taking a rest break. For sources requiring observation periods of greater than 20 minutes, the observer shall take a break of not less than 5 minutes and not more than 10 minutes after every 15 to 20 minutes of observation. If continuous observations are desired for extended time periods, two observers can alternate between making observations and taking breaks.

11.5 Recording Observations. Record the accumulated time of the observation period on the data sheet as the observation period duration. Record the accumulated time emissions were observed on the data sheet as the emission time. Record the clock time the observation period began and ended, as well as the clock time any observer breaks began and ended.

12.0 Data Analysis and Calculations.

If the applicable subpart requires that the emission rate be expressed as an emission frequency (in percent), determine this value as follows: Divide the accumulated emission time (in seconds) by the duration of the observation period (in seconds) or by any minimum observation period required in the applicable subpart, if the actual observation period is less than the required period, and multiply this quotient by 100.

13.0 Method Performance. [Reserved]

14.0 Pollution Prevention. [Reserved]

15.0 Waste Management. [Reserved]

16.0 References.

1. Missan, R., and A. Stein. Guidelines for Evaluation of Visible Emissions Certification, Field Procedures, Legal Aspects, and Background Material. EPA Publication No. EPA-340/1-75-007. April 1975.

2. Wohlschlegel, P., and D.E. Wagoner. Guideline for Development of a Quality Assurance Program: Volume IX--Visual Determination of Opacity Emissions from Stationary Sources. EPA Publication No. EPA-650/4-74-005i. November 1975.

17.0 Tables, Diagrams, Flowcharts, and Validation Data.

FUGITIVE OR SMOKE EMISSION INSPECTION
OUTDOOR LOCATION

Company Location Company Rep.	Observer Affiliation Date
Sky Conditions Precipitation	Wind Direction Wind Speed
Industry	Process Unit

Sketch process unit: indicate observer position relative to source; indicate potential emission points and/or actual emission points.

OBSERVATIONS	Clock Time	Observation period duration, min:sec	Accumulated emission time, min:sec
Begin Observation	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______		
End Observation		______	______
	______		

Figure 22-1

FUGITIVE OR SMOKE EMISSION INSPECTION
INDOOR LOCATION

Company Location Company Rep.	Observer Affiliation Date
Industry	Process Unit

Light type (fluorescent, incandescent, natural)
Light location (overhead, behind observer, etc.)
Illuminance (lux or footcandles)
Sketch process unit: indicate observer position relative to source; indicate potential emission points and/or actual emission points.

OBSERVATIONS	Clock Time	Observation period duration, min:sec	Accumulated emission time, min:sec
Begin	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
End Observation	______		

Figure 22-2

EMISSION MEASUREMENT TECHNICAL INFORMATION CENTER
NSPS TEST METHOD

Prepared by **Emission Measurement Branch** EMTIC TM-009
Technical Support Division, OAQPS, EPA October 25, 1990

Method 9 - Visual Determination of the Opacity of Emissions from Stationary Sources

INTRODUCTION

(a) Many stationary sources discharge visible emissions into the atmosphere; these emissions are usually in the shape of a plume. This method involves the determination of plume opacity by qualified observers. The methods includes procedures for the training and certification of observers and procedures to be used in the field for determination of plume opacity.

(b) The appearance of a plume as viewed by an observer depends upon a number of variables, some of which may be controllable in the field. Variables which can be controlled to an extent to which they no longer exert a significant influence upon plume appearance include: angle of the observer with respect to the plume; angle of the observer with respect to the sun; point of observation of attached and detached steam plume; and angle of the observer with respect to a plume emitted from a rectangular stack with a large length to width ratio. The method includes specific criteria applicable to these variables.

(c) Other variables which may not be controllable in the field are luminescence and color contrast between the plume and the background against which the plume is viewed. These variables exert an influence upon the appearance of a plume as viewed by an observer and can affect the ability of the observer to assign accurately opacity values to the observed plume. Studies of the theory of plume opacity and field studies have demonstrated that a plume is most visible and presents the greatest apparent opacity when viewed against a contrasting background. Accordingly, the opacity of a plume viewed under conditions where a contrasting background is present can be assigned with the greatest degree of accuracy. However, the potential for a positive error is also the greatest when a plume is viewed under such contrasting conditions. Under conditions presenting a less contrasting background, the apparent opacity of a plume is less and approaches zero as the color and luminescence contrast decrease toward zero. As a result, significant negative bias and negative errors can be made when a plume is viewed under less contrasting conditions. A negative bias decreases rather than increases the possibility that a plant operator will be incorrectly cited for a violation of opacity standards as a result of observer error.

(d) Studies have been undertaken to determine the magnitude of positive errors made by qualified observers while reading plumes under contrasting conditions and using the procedures set forth in this method. The results of these studies (field trials) which involve a total of 769 sets of 25 readings each are as follows:

(1) For black plumes (133 sets at a smoke generator), 100 percent of the sets were read with a positive error of less than 7.5 percent opacity; 99 percent were read with a positive error of less than 5 percent opacity. (Note: For a set, positive error = average opacity determined by observers' 25 observations -average opacity determined from transmissometer's 25 recordings.)

(2) For white plumes (170 sets at a smoke generator, 168 sets at a coal-fired power plant, 298 sets at a sulfuric acid plant), 99 percent of the sets were

read with a positive error of less than 7.5 percent opacity; 95 percent were read with a positive error of less than 5 percent opacity.

(e) The positive observational error associated with an average of twenty-five readings is therefore established. The accuracy of the method must be taken into account when determining possible violations of applicable opacity standards.

1. PRINCIPLE AND APPLICABILITY

1.1 Principle. The opacity of emissions from stationary sources is determined visually by a qualified observer.

1.2 Applicability. This method is applicable for the determination of the opacity of emissions from stationary sources pursuant to § 60.11(b) and for visually determining opacity of emissions.

2. PROCEDURES

The observer qualified in accordance with Section 3 of this method shall use the following procedures for visually determining the opacity of emissions.

2.1 Position. The qualified observer shall stand at a distance sufficient to provide a clear view of the emissions with the sun oriented in the 140° sector to his back. Consistent with maintaining the above requirement, the observer shall, as much as possible, make his observations from a position such that his line of vision is approximately perpendicular to the plume direction and, when observing opacity of emissions from rectangular outlets (e.g., roof monitors, open baghouses, noncircular stacks), approximately perpendicular to the longer axis of the outlet. The observer's line of sight should not include more than one plume at a time when multiple stacks are involved, and in any case the observer should make his observations with his line of sight perpendicular to the longer axis of such a set of multiple stacks (e.g., stub stacks on baghouses).

2.2 Field Records. The observer shall record the name of the plant, emission location, facility type, observer's name and affiliation, and the date on a field data sheet (Figure 9-1). The time, estimated distance to the emission location, approximate wind direction, estimated wind speed, description of the sky condition (presence and color of clouds), and plume background are recorded on a field data sheet at the time opacity readings are initiated and completed.

Figure 9-1. Record of visual determination of opacity.

Company______________________________

Location______________________________

Test No.______________________________

Date______________________________

Type Facility______________________________

Control Device______________________________

Hours of Observation________________________

Observer______________________________

Observer Certification Date________________

Point of Emissions________________________

Observer Affiliation__________

Height of Discharge Point____

CLOCK TIME	Initial			Final
OBSERVER LOCATION				
Distance to discharge				
Direction from discharge				
Height of observation point				
BACKGROUND DESCRIPTION				
WEATHER CONDITIONS				
Wind Direction				
Wind Speed				
Ambient Temperature				
SKY CONDITIONS (clear, overcast, % clouds, etc.)				
PLUME DESCRIPTION				
Color				
Distance Visible				
OTHER INFORMATION				

SUMMARY OF AVERAGE OPACITY

Set Number	Time	Opacity	
	Start - End	Sum	Average

Readings ranged from ___ to ___ % opacity.

The source was/was not in compliance with ___ at the time evaluation was made.

Figure 9-2. Observation record.

Page ___ of ___

Company ____________________ Observer ____________________

Location ____________________ Type facility ____________________

Test Number ____________________ Point of emissions ____________________

Hr	Min	Seconds 0	15	30	45	Steam plume (check if applicable) Attached	Detached	Comments
	0							
	1							
	2							
	3							
	4							
	5							
	6							
	7							
	8							
	9							
	10							
	11							
	12							
	13							
	14							
	15							
	16							
	17							
	18							
	19							
	20							
	21							
	22							
	23							
	24							
	25							
	26							
	27							
	28							
	29							

Figure 9-2. Observation record (continued).

Page ___ of ___

Company ____________________ Observer ____________________

Location ____________________ Type facility ____________________

Test Number ____________________ Point of emissions ____________________

		Seconds				Steam plume (check if applicable)		Comments
Hr	Min	0	15	30	45	Attached	Detached	
	30							
	31							
	32							
	33							
	34							
	35							
	36							
	37							
	38							
	39							
	40							
	41							
	42							
	43							
	44							
	45							
	46							
	47							
	48							
	49							
	50							
	51							
	52							
	53							
	54							
	55							
	56							
	57							
	58							
	59							

2.3 Observations. Opacity observations shall be made at the point of greatest opacity in that portion of the plume where condensed water vapor is not present. The observer shall not look continuously at the plume but instead shall observe the plume momentarily at 15-second intervals.

2.3.1 Attached Steam Plumes. When condensed water vapor is present within the plume as it emerges from the emission outlet, opacity observations shall be made beyond the point in the plume at which condensed water vapor is no longer visible. The observer shall record the approximate distance from the emission outlet to the point in the plume at which the observations are made.

2.3.2 Detached Steam Plume. When water vapor in the plume condenses and becomes visible at a distinct distance from the emission outlet, the opacity of emissions should be evaluated at the emission outlet prior to the condensation of water vapor and the formation of the steam plume.

2.4 Recording Observations. Opacity observations shall be recorded to the nearest 5 percent at 15-second intervals on an observational record sheet. (See Figure 9-2 for an example.) A minimum of 24 observations shall be recorded. Each momentary observation recorded shall be deemed to represent the average opacity of emissions for a 15-second period.

2.5 Data Reduction. Opacity shall be determined as an average of 24 consecutive observations recorded at 15-second intervals. Divide the observations recorded on the record sheet into sets of 24 consecutive observations. A set is composed of any 24 consecutive observations. Sets need not be consecutive in time and in no case shall two sets overlap. For each set of 24 observations, calculate the average by summing the opacity of the 24 observations and dividing this sum by 24. If an applicable standard specifies an averaging time requiring more than 24 observations, calculate the average for all observations made during the specified time period. Record the average opacity on a record sheet. (See Figure 9-1 for an example.)

3. QUALIFICATION AND TESTING

3.1 Certification Requirements. To receive certification as a qualified observer, a candidate must be tested and demonstrate the ability to assign opacity readings in 5 percent increments to 25 different black plumes and 25 different white plumes, with an error not to exceed 15 percent opacity on any one reading and average error not to exceed 7.5 percent opacity in each category. Candidates shall be tested according to the procedures described in Section 3.2. Smoke generators used pursuant to Section 3.2 shall be equipped with a smoke meter which meets the requirements of Section 3.3. The certification shall be valid for a period of 6 months, at which time the qualification procedure must be repeated by any observer in order to retain certification.

3.2 Certification Procedure. The certification test consists of showing the candidate a complete run of 50 plumes--25 black plumes and 25 white plumes-generated by a smoke generator. Plumes within each set of 25 black and 25 white runs shall be presented in random order. The candidate assigns an opacity value to each plume and records his observation on a suitable form. At the completion of each run of 50 readings, the score of the candidate is determined. If a candidate fails to qualify, the complete run of 50 readings must be repeated in any retest. The smoke test may be administered as part of a smoke school or training program and may be preceded by training or familiarization runs of the smoke generator during which candidates are shown black and white plumes of known opacity.

3.3 Smoke Generator Specifications. Any smoke generator used for the purposes of Section 3.2 shall be equipped with a smoke meter installed to measure opacity across the diameter of the smoke generator stack. The smoke meter output shall display in-stack opacity based upon a pathlength equal to the stack exit diameter, on a full 0 to 100 percent chart recorder scale. The smoke meter optical design and performance shall meet the specifications shown in Table 91. The smoke meter shall be calibrated as prescribed in Section 3.3.1 prior to the conduct of each smoke reading test. At the completion of each test, the zero and span drift shall be checked and if the drift exceeds ±1 percent opacity, the condition shall be corrected prior to conducting any subsequent test runs. The smoke meter shall be demonstrated, at the time of installation, to meet the specifications listed in Table 9-1. This demonstration shall be repeated following any subsequent repair or replacement of the photocell or associated electronic circuitry including the chart recorder or output meter, or every 6 months, whichever occurs first.

TABLE 9-1 - SMOKE METER DESIGN AND PERFORMANCE SPECIFICATIONS

Parameter	Specification
a. Light Source	Incandescent lamp operated at nominal rated voltage
b. Spectral reponse of photocell	Photopic (daylight spectral response of the human eye - Citation 3)
c. Angle of view	15° maximum total angle
d. Angle of projection	15° maximum total angle
e. Calibration error	±3% opacity, maximum
f. Zero and span drift	±1% opacity, 30 minutes
g. Response time	5 seconds

3.3.1 Calibration. The smoke meter is calibrated after allowing a minimum of 30 minutes warmup by alternately producing simulated opacity of 0 percent and 100 percent. When stable response at 0 percent or 100 percent is noted, the smoke meter is adjusted to produce an output of 0 percent or 100 percent, as appropriate. This calibration shall be repeated until stable 0 percent and 100 percent opacity values may be produced by alternately switching the power to the light source on and off while the smoke generator is not producing smoke.

3.3.2 Smoke Meter Evaluation. The smoke meter design and performance are to be evaluated as follows:

3.3.2.1 Light Source. Verify from manufacturer's data and from voltage measurements made at the lamp, as installed, that the lamp is operated within ±5 percent of the nominal rated voltage.

3.3.2.2 Spectral Response of Photocell. Verify from manufacturer's data that the photocell has a photopic response; i.e., the spectral sensitivity of the cell shall closely approximate the standard spectral-luminosity in (b) of Table 91.

3.3.2.3 Angle of View. Check construction geometry to ensure that the total angle of view of the smoke plume, as seen by the photocell, does not exceed 15°. The total angle of view may be calculated from: $\grave{E} = 2 \tan^{-1} (d/2L)$, where $\grave{E}$ = total angle of view; d = the sum of the photocell diameter + the diameter of the limiting aperture; and L = the distance from the photocell to the limiting aperture. The limiting aperture is the point in the path between the photocell and the smoke plume where the angle of view is most restricted. In smoke generator smoke meters this is normally an orifice plate.

3.3.2.4 Angle of Projection. Check construction geometry to ensure that the total angle of projection of the lamp on the smoke plume does not exceed 15°. The total angle of projection may be calculated from: $\grave{E} = 2 \tan^{-1} (d/2L)$, where $\grave{E}$ = total angle of projection; d = the sum of the length of the lamp filament + the diameter of the limiting aperture; and L = the distance from the lamp to the limiting aperture.

3.3.2.5 Calibration Error. Using neutral-density filters of known opacity, check the error between the actual response and the theoretical linear response of the smoke meter. This check is accomplished by first calibrating the smoke meter according to Section 3.3.1 and then inserting a series of three neutral-density filters of nominal opacity of 20, 50, and 75 percent in the smoke meter pathlength. Filters calibrated within 2 percent shall be used. Care should be taken when inserting the filters to prevent stray light from affecting the meter. Make a total of five nonconsecutive readings for each filter. The maximum error on any one reading shall be 3 percent opacity.

3.3.2.6 Zero and Span Drift. Determine the zero and span drift by calibrating and operating the smoke generator in a normal manner over a 1-hour period. The drift is measured by checking the zero and span at the end of this period.

3.3.2.7 Response Time. Determine the response time by producing the series of five simulated 0 percent and 100 percent opacity values and observing the time required to reach stable response. Opacity values of 0 percent and 100 percent may be simulated by alternately switching the power to the light source off and on while the smoke generator is not operating.

4. BIBLIOGRAPHY

1. Air Pollution Control District Rules and Regulations, Los Angeles County Air Pollution Control District, Regulation IV, Prohibitions, Rule 50.

2. Weisburd, Melvin I., Field Operations and Enforcement Manual for Air, U.S. Environmental Protection Agency, Research Triangle Park, NC, APTD-1100, August 1972, pp. 4.1-4.36.

3. Condon. E.U., and Odishaw, H., Handbook of Physics, McGraw-Hill Co., New York, NY, 1958, Table 3.1, p. 6-52.